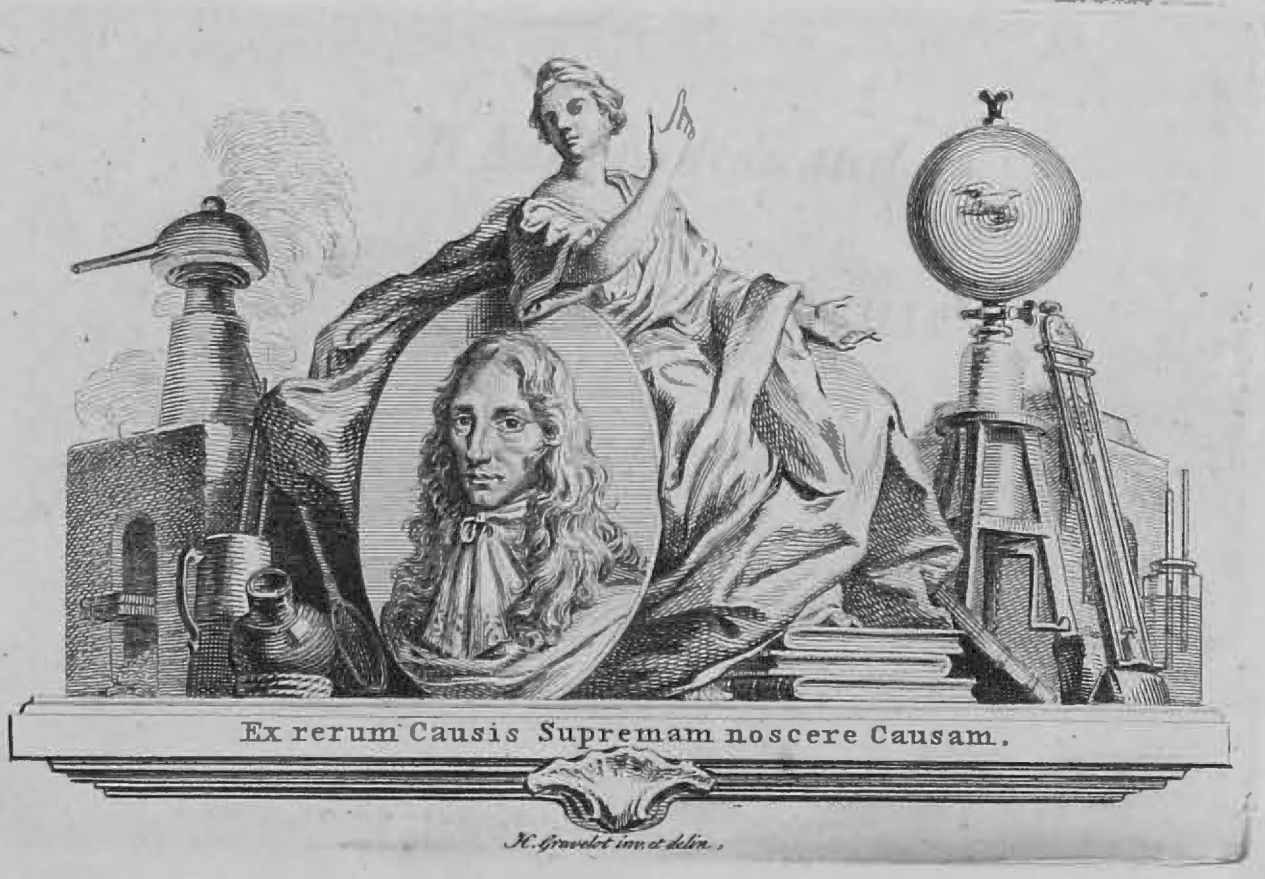
THE

WORKS

OF THE HONOURABLE

ROBERT BOYLE.

VOLUME II.



LONDON:

Printed for A. MILLAR, oppoſite *Catharine-Street*, in the *Strand*.

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TO

THE RIGHT HONOURABLE

JOHN Earl of ORRERY,

THIS

SECOND VOLUME

OF THE

WORKS

OF

The Honourable *ROBERT BOYLE*

Is humbly dedicated,

By his LORDSHIP's

Moſt devoted and

Moſt obedient Servant,

Andrew Millar.

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EXPERIMENTS
AND
CONSIDERATIONS
TOUCHING
COLOURS.

First occaſionally written, among ſome other *Eſſays*, to a Friend; and now ſuffer'd to come abroad as

The BEGINNING of an

EXPERIMENTAL HISTORY of COLOURS.

The PREFACE.

HAVING, in convenient places of the following treatiſe, mentioned the motives, that induced me to write it, and the ſcope I propoſed to my ſelf in it, I think it ſuperfluous to entertain the reader now with what he will meet with hereafter. And I ſhould judge it needleſs, to trouble others, or my ſelf, with any thing of preface; were it not, that I can ſcarce doubt, but this book will fall into the hands of ſome readers, who being unacquainted with the difficulty of attempts of this nature, will think it ſtrange that I ſhould publiſh any thing about colours, without a particular theory of them. But I dare expect, that intelligent and equitable readers will conſider on my behalf, that the profeſſed deſign of this treatiſe is to deliver things rather hiſtorical than dogmatical, and conſequently, if I have added divers new ſpeculative conſiderations and hints which perhaps may afford no deſpicable aſſiſtance towards the framing of a ſolid and comprehenſive hypotheſis, I have done at leaſt as much as I promiſed, or as the nature of my undertaking exacted. But another thing there is, which if it ſhould be objected, I fear I ſhould not be able ſo eaſily to anſwer it; and that is, that in the following treatiſe (eſpecially in the third part of it) the experiments might have been better marſhalled, and ſome of them delivered in fewer words. For I muſt confeſs, that this Eſſay was written to a private friend, and that too by ſnatches, at ſeveral times, and places, and (after my manner) in looſe ſheets, of which I oftentimes had not all by me that I had already written, when I was writing more; ſo that it needs be no wonder if all the experiments be not ranged to the beſt advantage, and if ſome connexions and conſecutions of them might eaſily have been mended: eſpecially ſince, having careleſly laid by the looſe papers, for ſeveral years after they were written, when I came to put them together to diſpatch them to the preſs, I found ſome of thoſe I reckoned upon, to be very unſeaſonably wanting. And to make any great change in the order of the reſt was more than the printer's importunity, and that of my own avocations (and perhaps alſo conſiderable ſollicitations) would permit. But though ſome few preambles of the particular experiments might have (perchance) been ſpared, or ſhortened, if I had had all my papers under my view at once; yet in the moſt of thoſe introductory paſſages, the reader will (I hope) find hints, or advertiſements, as well as tranſitions. If I ſometimes ſeem to inſiſt long upon the circumſtances of a trial, I hope I ſhall be eaſily excuſed by thoſe, that both know how nice divers experiments of colours are, and conſider, that I was not barely to relate them, but ſo as to teach a young gentleman to make them. And if I was not ſollicitous to make a nicer diviſion of the whole treatiſe, than into three parts, whereof the one contains ſome conſiderations about colours in general; the other exhibits a ſpecimen of an account of particular colours, exemplified in whiteneſs and blackneſs; and the third, promiſcuous experiments about the remain-

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ing colours (eſpecially red) in order to a theory of them: If, I ſay, I contented my ſelf with this eaſy diviſion of my diſcourſe, it was perhaps, becauſe I did not think it ſo neceſſary to be curious about the method or contrivance of a treatiſe, wherein I do not pretend to preſent my reader with a compleat fabrick, or ſo much as model; but only to bring in materials proper for the building. And if I did not well know, how ingenious the curioſity and civility of friends makes them, to perſuade men by ſpecious allegations, to gratify their deſires; I ſhould have been made to believe by perſons very well qualified to judge of matters of this nature, that the following experiments will not need the addition of accurate method and ſpeculative notions to procure acceptance for the treatiſe that contains them. For it hath been repreſented, that in moſt of them, as the novelty will make them ſurprizing, and the quickneſs of performance, keep them from being tedious; ſo the ſenſible changes, that are effected by them, are ſo manifeſt, ſo great, and ſo ſudden, that ſcarce any will be diſpleaſed to ſee them, and thoſe that are any thing curious will ſcarce be able to ſee them, without finding themſelves excited to make reflections upon them. But though with me, who love to meaſure phyſical things by their uſe, not their ſtrangeneſs, or prettineſs, the partiality of others prevails not to make me over-value theſe, or look upon them in themſelves as other than trifles; yet I confeſs, that ever ſince I did divers years ago ſhew ſome of them to a learned company of *Virtuoſi*, ſo many perſons of differing conditions, and even ſexes, have been curious to ſee them, and pleaſed not to diſlike them, that I cannot deſpair, but that by complying with thoſe that urge the publication of them, I may both gratify and excite the curious, and lay perhaps a foundation, whereon either others or my ſelf may in time ſuperſtruct a ſubſtantial theory of colours. And if *Ariſtotle*, after his maſter *Plato*, have rightly obſerved admiration to be the parent of philoſophy, the wonder, ſome of theſe trifles have been wont to produce in all ſorts of beholders, and the acceſs they have ſometimes gained even to the cloſets of ladies, ſeem to promiſe, that ſince the ſubject is ſo pleaſing, that the ſpeculation appears as delightful as difficult, ſuch eaſy and recreative experiments, which require but little time, or charge, or trouble in the making, and when made are ſenſible and ſurprizing enough, may contribute more than others, (far more important, but as much more difficult) to recommend thoſe parts of learning (chymiſtry and corpuſcular philoſophy) by which they have been produced, and to which they give teſtimony even to ſuch kind of perſons, as value a pretty trick more than a true notion, and would ſcarce admit philoſophy, if it approached them in another dreſs. Without the ſtrangeneſs or endearments of pleaſantneſs to recommend it, I know, that I do but ill conſult my own advantage in the conſenting to the publication of the following treatiſe: for thoſe things, which, whilſt men knew not how they were performed, appeared ſo ſtrange, will, when the way of making them, and the grounds on which I deviſed them, ſhall be publick, quickly loſe all, that their being rarities, and their being thought myſteries, contributed to recommend them. But it is fitter for mountebanks than naturaliſts to deſire to have their diſcoveries rather admired than underſtood; and for my part I had much rather deſerve the thanks of the ingenious, than enjoy the applauſe of the ignorant. And if I can ſo far contribute to the diſcovery of the nature of colours, as to help the curious to it, I ſhall have reached my end, and ſaved my ſelf ſome labour, which elſe I may chance to be tempted to undergo in proſecuting that ſubject, and adding to this treatiſe, which I therefore call a hiſtory, becauſe it chiefly contains matters of fact, and which hiſtory the title declares me to look upon but as begun. Becauſe though that above a hundred, not to ſay a hundred and fifty experiments, (ſome looſe, and others interwoven amongſt the diſcourſes themſelves) may ſuffice to give a beginning to a hiſtory not hitherto, that I know, begun by any; yet the ſubject is ſo fruitful, and ſo worthy, that thoſe, who are curious of theſe matters, will be far more wanting to themſelves than I can ſuſpect, if what I now publiſh prove any more than a beginning. For, as I hope my endeavours may afford them ſome aſſiſtance towards this work, ſo thoſe endeavours are too much unfiniſhed to give them any diſcouragement, as if there were little left for others to do towards the hiſtory of colours.

For (firſt) I have been willing to leave unmentioned the moſt part of thoſe phænomena of colours, that nature preſents us of her own accord, (that is, without being guided or over-ruled by man;) ſuch as the different colours, that ſeveral ſorts of fruits paſs through before they are perfectly ripe, and thoſe that appear upon the fading of flowers and leaves, and the putrefaction (and its ſeveral degrees) of fruits, *&c.* together with a thouſand other obvious inſtances of the changes of colours. Nor have I much meddled with thoſe familiar phænomena, wherein man is not an idle ſpectator; ſuch as the greenneſs produced by ſalt in beef much powdered, and the redneſs produced in the ſhells of lobſters upon the boiling of thoſe fiſhes: for I was willing to leave the gathering of obſervations to thoſe, that have not the opportunity to make experiments. And for the ſame reaſons, among others, I did purpoſely omit the lucriferous practice of tradeſmen about colours; as the ways of making pigments, of blanching wax, of dying ſcarlet, *&c.* though to divers of them I be not a ſtranger, and of ſome I have my ſelf made trial.

Next; I did purpoſely paſs by divers experiments of other writers that I had made trial of, (and that not without regiſtring ſome of their events) unleſs I could ſome way or other improve them, becauſe I wanted leiſure to inſert them, and had thoughts of proſecuting the work once begun of laying together thoſe I had

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examined by themſelves, in caſe of my not being prevented by others diligence. So that there remains not a little, among the things that are already publiſhed, to employ thoſe, that have a mind to exerciſe themſelves in repeating and examining them. And I will not undertake, that none of the things delivered, even in this treatiſe, though never ſo faithfully ſet down, may not prove to be thus far of this ſort, as to afford the curious ſomewhat to add about them. For I remember, that I have ſomewhere in the book itſelf acknowledged, that having written it by ſnatches, partly in the country and partly at unſeaſonable times of the year, when the want of fit inſtruments, and of a competent variety of flowers, ſalts, pigments, and other materials made me leave ſome of the following experiments, (eſpecially thoſe about emphatical colours) far more unfiniſhed than they ſhould have been, if it had been as eaſy for me to ſupply what was wanting to compleat them, as to diſcern. Thirdly, to avoid diſcouraging the young gentleman I call *Pyrophilus*, whom the leſs familiar and more laborious operations of chymiſtry would probably have frighted, I purpoſely declined, in what I writ to him, the ſetting down any number of ſuch chymical experiments, as, by being very elaborate or tedious, would either require much ſkill, or exerciſe his patience. And yet that this ſort of experiments is exceedingly numerous, and might more than a little enrich the hiſtory of colours, thoſe that are verſed in chymical proceſſes will, I preſume, eaſily allow me.

And (laſtly) for as much as I have occaſion more than once in my ſeveral writings to treat either purpoſely or incidentally of matters relating to colours, I did not, perhaps, conceive my ſelf oblig'd, to deliver in one treatiſe all that I would ſay concerning that ſubject.

But to conclude, by ſumming up what I would ſay concerning what I have, and what I have not done, in the following papers; I ſhall not (on the one ſide) deny, that conſidering, that I pretended not to write an accurate treatiſe of colours, but an occaſional eſſay to acquaint a private friend with what then occurred to me of the things I had thought or tried concerning them; I might preſume I did enough for once, if I did clearly and faithfully ſet down, though not all the experiments I could, yet at leaſt ſuch a variety of them, that an attentive reader, that ſhall conſider the grounds on which they have been made, and the hints that are purpoſely (though diſperſedly) couched in them, may eaſily compound them, and otherwiſe vary them, ſo as very much to increaſe their number. And yet (on the other ſide) I am ſo ſenſible both of how much I have, either out of neceſſity or choice, left undone, and of the fruitfulneſs of the ſubject I have begun to handle; that though I had performed far more than it is like many readers will judge I have, I ſhould yet be very free to let them apply to my attempts that of *Seneca*, where having ſpoken of the ſtudy of nature's myſteries, and particularly of the cauſe of earth-quakes, he ſubjoins; *Nulla res conſummata eſt dum incipit. Nec in hac tantum re omnium maxima ac inveteratiſſimâ, in quâ etiam cum multum actum erit, omnis ætas, quod agat, inveniet; ſed in omni alio negotio, longè ſemper à perfecto fuere principia.* L. Annæi Senecæ Natur. Quæſt. l. 6. c. 5.

The Publiſher to the Reader.

Friendly Reader,

HERE is preſented to thy view one of the abſtruſeſt as well as the genteeleſt ſubjects of natural philoſophy, the *Experimental Hiſtory of Colours*; which, though the noble author be pleaſed to think but begun, yet I muſt take leave to ſay, that I think it ſo well begun, that the work is more than half diſpatched. Concerning which I cannot but give this advertiſement to the reader, that I have heard the author expreſs himſelf, that it would not ſurprize him, if it ſhould happen to be objected, that ſome of theſe experiments have been already publiſhed, partly by chymiſts, and partly by two or three very freſh writers upon other ſubjects. And though the number of theſe experiments be but very ſmall, and though they be none of the conſiderableſt, yet it may on this occaſion be further repreſented, that it is eaſy for our author to name ſeveral men, (of whoſe number I can truly name myſelf) who remember either their having ſeen him make, or their having read his accounts of the experiments delivered in the following tract ſeveral years ſince, and long before the publication of the books, wherein they are mentioned. Nay, in divers paſſages (where he could do it without any great inconvenience) he hath ſtruck out experiments, which he had tried many years ago, becauſe he ſince found them divulged by perſons, from whom he had not the leaſt hint of them. Which yet is not touched, with deſign to reflect upon any ingenious man, as if he were a plagiary: for, though our generous author were not reſerved enough in ſhewing his experiments to thoſe that expreſſed a curioſity to ſee them (amongſt whom a very learned man hath been pleaſed publickly to acknowledge it ſeveral years ago *;) yet the ſame thing may be well enough lighted on by perſons, that know nothing of one

* He that deſires more inſtances of this kind and matter, that according to this doctrine may much help the theory of colours, and particularly the force both of ſulphureous and volatile, as likewiſe of alcalizate and acid ſalts, and in what particulars colours likely depend not in their cauſation from any ſalt at all; may beg his information from Mr. *Boyle*, who hath ſome while ſince honoured me with the ſight of his papers concerning this ſubject, containing many excellent experiments, made by him for the elucidation of this doctrine, &c. Dr. *R. Sharrock*, in his ingenious and uſeful *Hiſtory of the Propagation and Improvement of Vegetables*, publiſhed in the year 1660.

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one another. And eſpecially chymical laboratories may many times afford the ſame phænomenon, about colours, to ſeveral perſons, at the ſame or differing times. And as for the few phænomena mentioned in the ſame chymical writers, as well as in the following treatiſe, our author hath given an account, why he did not decline rejecting them in the annotations upon the 47th experiment of the third part. Not here to mention, what he elſewhere ſaith, to ſhew what uſe may be juſtifiably made of experiments not of his own deviſing by a writer of natural hiſtory, if, what he employs of other mens, be well examined or verified by himſelf.

In the mean time, this treatiſe is ſuch, that there needs no other invitation to peruſe it, but that 'tis compoſed by one of the deepeſt and moſt indefatigable ſearchers of nature, which, I think the world, as far as I know it, affords. For mine own part, I feel a ſecret joy within me, to ſee ſuch beginnings upon ſuch themes, it being demonſtratively true, *mota facilius moveri*; which cauſeth me to entertain ſtrong hopes, that this illuſtrious virtuoſo and reſtleſs inquirer into nature's ſecrets will not ſtop here, but go on and proſper in the diſquiſition of the other principal colours, green, red, and yellow. The reaſoning faculty ſet once afloat will be carried on, and that with eaſe; eſpecially, when the productions thereof meet, as they do here, with ſo greedy an entertainment at home and abroad. I am confident, that the Royal Society, lately conſtituted by his moſt Excellent Majeſty *for improving Natural Knowledge* will judge it their intereſt to exhort our author to the proſecution of this argument; conſidering, how much it is their deſign and buſineſs to accumulate a good ſtock of ſuch accurate obſervations and experiments, as may afford them and their offſpring genuine matter to raiſe a maſculine philoſophy upon, whereby the mind of man may be ennobled with the knowledge of ſolid truths, and the life of man benefited with ampler accommodations, than it hath been hitherto.

Our great author, one of the pillars of that illuſtrious corporation, is conſtantly furniſhing large ſymbola's to this work; and is now fallen, as you ſee, upon ſo comprehenſive and important a theme, as will, if inſiſted on and compleated, prove one of the conſiderableſt pieces of that ſtructure. To which if he ſhall pleaſe to add his treatiſe of heat and flame, as he is ready to publiſh his experimental accounts of cold; I eſteem, the world will be obliged to him for having ſhewed them both the right and left-hand of nature, and the operations thereof.

The conſidering reader will by this very treatiſe ſee abundant cauſe to ſollicit the author for more. Sure I am, that of whatever of the productions of his ingeny comes into foreign parts (where I am happy in the acquaintance of many intelligent friends) is highly valued; and to my knowledge, there are thoſe among the French, that have lately begun to learn Engliſh, on purpoſe to enable themſelves to read his books, being impatient of their traduction into Latin. If I durſt ſay all I know of the elogies received by me from abroad concerning him, I ſhould perhaps make this preamble too prolix, and certainly offend the modeſty of our author.

Wherefore I ſhall leave this, and conclude with deſiring the reader, that if he meet with other faults beſides thoſe, that the Errata take notice of (as I believe he may) he will pleaſe to conſider both the weakneſs of the author's eyes, for not reviewing, and the manifold avocations of the publiſher for not doing his part; who taketh his leave with inviting thoſe, that have alſo conſidered this nice ſubject experimentally, to follow the example of our noble author, and impart ſuch and the like perfomances to the now very inquiſitive world. Farewel.

H. O.

THE

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THE EXPERIMENTAL HISTORY OF COLOURS BEGUN.

THE FIRST PART.

CHAP. I.

1. I HAVE ſeen you ſo paſſionately addicted, *Pyrophilus*, to the delightful art of limning and painting, that I cannot but think myſelf obliged to acquaint you with ſome of thoſe things that have occurred to me concerning the changes of colours. And I may expect that I ſhall as well ſerve the Virtuoſi in general, as gratify you in particular, by furniſhing a perſon, who, I hope, will both improve my communications, and communicate his improvements, with ſuch experiments and obſervations as may both invite you to inquire ſeriouſly into the nature of colours, and aſſiſt you in the inveſtigation of it. This being the principal ſcope of the following tract, I ſhould do that which might prevent my own deſign, if I ſhould here attempt to deliver you an accurate and particular theory of colours; for that were to preſent you with what I deſire to receive from you; and, as far as in me lay, to make that ſtudy needleſs, to which I would engage you.

2. WHEREFORE my preſent work ſhall be but to divert and recreate, as well as excite you by the delivery of matters of fact, ſuch as you may for the moſt part try with much eaſe, and poſſibly not without ſome delight. And leſt you ſhould expect any thing of elaborate or methodical in what you will meet with here, I muſt confeſs to you before-hand, that the ſeaſons I was wont to chuſe to deviſe and try experiments about colours, were thoſe days, wherein having taken phyſic, and finding my ſelf as unfit to ſpeculate, as unwilling to be altogether idle, I choſe this diverſion as a kind of mean betwixt the one and the other. And I have the leſs ſcrupled to ſet down the following experiments, as ſome of them came to my mind, and as the notes wherein I had ſet down the reſt, occurred to my hands; that by declining a methodical way of delivering them, I might leave you and my ſelf the greater liberty and convenience to add to them, and tranſpoſe them as ſhall appear expedient.

3. YEA, that you may not think me too reſerved, or look upon an inquiry made up of mere narratives, as ſomewhat jejune, I am content to premiſe a few conſiderations, that now offer themſelves to my thoughts, which relate in a more general way, either to the nature of colours, or to the ſtudy of it. And I ſhall inſert an eſſay, as well ſpeculative as hiſtorical, of the nature of whiteneſs and blackneſs, that you may have a ſpecimen of the hiſtory of colours, I have ſometimes had thoughts of; and if you diſlike not the method I have made uſe of, I hope you, and ſome of the Virtuoſi your friends, may be thereby invited to go thorough with red, blue, yellow, and the reſt of the particular colours, as I have done with white and black, but with far more ſagacity and ſucceſs. And if I can invite ingenious men to undertake ſuch taſks, I doubt not but the curious will quickly obtain a better account of colours, than as yet we have, ſince in our method the theorical part of the inquiry being attended, and as it were interwoven with the hiſtorical conjectures, the philoſophy of colours will be promoted by the indiſputable experiments.

CHAP. II.

1. TO come then in the firſt place to our more general conſiderations, I ſhall begin with ſaying ſomething as to the importance of examining the colours of bodies. For there are ſome, eſpecially chymiſts, who think that a conſiderable diverſity of colours does conſtantly argue an equal diverſity of nature, in the bodies wherein it is conſpicuous; but I confeſs I am not altogether of their mind: for not to mention changeable taffaties, the blue and golden necks of pigeons, and divers water-fowl, rainbows natural and artificial, and other bodies, whoſe colours the philoſophers have been pleaſed to call not real, but apparent and fantaſtical; not to inſiſt on theſe, I ſay, (for fear of needleſly engaging in a controverſy) we ſee in parrots, goldfinches, and divers other birds, not only that the contiguous feathers which are probably as near in properties as place, are ſome of them red, and others white, ſome of them blue, and others yellow, *&c.* but that in the ſeveral parts of the ſelf-ſame feather there may often be ſeen the greateſt diſparity of colours. And ſo in the leaves of tulips, july-flowers, and ſome other vegetables, the ſeveral leaves, and even the ſeveral

parts of the ſame leaf, although no difference have been obſerved in their other properties, are frequently found painted with very different colours. And ſuch a variety we have much more admired in that lovely plant which is commonly, and not unjuſtly called the *Marvel of Peru*; for of divers ſcores of fine flowers, which in its ſeaſon that gaudy plant does almoſt daily produce, I have ſcarce taken notice of any two that were dyed perfectly alike. But though, *Pyro*, ſuch things as theſe, among others, keep me from daring to affirm that the diverſity and change of colours does always argue any great difference or alteration betwixt, or in the bodies, wherein it is to be diſcerned; yet that oftentimes the alteration of colours does ſignify conſiderable alterations in the diſpoſition of parts of bodies, may appear in the extraction of tinctures, and divers other chymical operations, wherein the change of colours is the chief, and ſometimes the only thing, by which the artiſt regulates his proceeding, and is taught to know when 'tis ſeaſonable for him to leave off. Inſtances of this ſort are more obvious in divers ſorts of fruits, as cherries, plums, *&c.* wherein, according as the vegetable ſap is ſweetned, or otherwiſe ripened, by paſſing from one degree to another of maturation, the external part of the fruit paſſes likewiſe from one to another colour. But one of the nobleſt inſtances I have met with of this kind, is not ſo obvious; and that is the way of tempering ſteel to make gravers, drills, ſprings, and other mechanical inſtruments, which we have divers times both made artificers practiſe in our preſence, and tried our ſelves after the following manner. Firſt, the ſlender ſteel to be tempered is to be hardened by heating as much of it as is requiſite among glowing coals, till it be glowing hot, but it muſt not be quenched as ſoon as it is taken from the fire, (for that would make it too brittle, and ſpoil it) but muſt be held over a baſon of water, till it deſcend from a white heat to a red one, which as ſoon as ever you perceive, you muſt immediately quench as much as you deſire to harden in the cold water. The ſteel thus hardened will, if it be good, look ſomewhat white, and muſt be made bright at the end, that its change of colours may be there conſpicuous; and then holding it ſo in the flame of a candle, that the bright end may be, for about half an inch or more, out of the flame, that the ſmoak do not ſtain or ſully the brightneſs of it, you ſhall after a while ſee that clean end, which is almoſt contiguous to the flame, paſs very nimbly from one colour to another, as from a brighter yellow, to a deeper and reddiſh yellow, which artificers call a ſanguine; and from that to a fainter firſt, and then a deeper blue. And to bring home this experiment to our preſent purpoſe, it is found by daily experience, that each of theſe ſucceeding colours argue ſuch a change made in the texture of the ſteel, that if it be taken from the flame, and immediately quenched in the tallow (whereby it is ſettled in whatever temper it had before) when it is yellow, it is of ſuch a hardneſs as makes it fit for gravers, drills, and ſuch like tools; but if it be kept a few minutes longer in the flame till it grow blue, it becomes much ſofter, and unfit to make gravers for metals, but fit to make ſprings for watches, and ſuch like inſtruments, which are therefore commonly of that colour: and if the ſteel be kept in the flame, after this deep blue hath diſcloſed itſelf, it will grow ſo ſoft, as to need to be new hardened again, before it can be brought to a temper fit for drills or penknives. And I confeſs, *Pyro*, I have taken much pleaſure to ſee the colours run along from the parts of the ſteel contiguous to the flame, to the end of the inſtrument, and ſucceed one another ſo faſt, that if a man be not vigilant, to thruſt the ſteel into the tallow at the very nick of time, at which it has attained its due colour, he ſhall miſs of giving his tool the right temper. But becauſe the flame of a candle is offenſive to my weak eyes, and becauſe it is apt to either black or ſully the contiguous part of the ſteel which is held in it, and thereby hinder the change of colours from being ſo long and clearly diſcern'd, I have ſometimes made this experiment by laying the ſteel to be tempered upon a heated bar of iron, which we find alſo to be employed by ſome artificers in the tempering of ſuch great inſtruments, as are too big to be ſoon heated ſufficiently by the flame of a candle. And you may eaſily ſatisfy your ſelf, *Pyro*, of the differing hardneſs and toughneſs, which is aſcribed to ſteel tempered at different colours, if you break but ſome ſlender wires of ſteel ſo tempered, and obſerve how they differ in brittleneſs, and if with a file you alſo make trial of their various degrees of hardneſs.

2. BUT, *Pyrophilus*, I muſt not at preſent any further proſecute the conſideration of the importance of experiments about colours, not only becauſe you will in the following papers find ſome inſtances, that would here be preſented you out of their due place, of the uſe that may be made of ſuch experiments, in diſcovering in divers bodies what kind the ſalt is, that is predominant in them; but alſo becauſe a ſpeculative Naturaliſt might juſtly enough alledge, that as light is ſo pleaſing an object, as to be well worth our looking on, though it diſcovered to us nothing but it ſelf; ſo modified light, called colour, were worth our contemplation, though by underſtanding its nature we ſhould be taught nothing elſe. And however, I need not make either you or my ſelf excuſes for entertaining you on the ſubject I am now about to treat of; ſince the pleaſure *Pyro* takes in mixing and laying on of colours, will I preſume keep him, and will (I am ſure) keep me from thinking it troubleſome to ſet down, eſpecially after the tedious proceſſes (about other matters) wherewith I fear I may have tired him, ſome eaſy, and not unpleaſant experiments relating to that ſubject.

3. BUT, before we deſcend to the more particular conſiderations we are to preſent you concerning colours, I preſume it will be ſeaſonable to propoſe at the very entrance a diſtinction;

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diſtinction; the ignorance or neglect of which, ſeems to me to have frequently enough occaſioned either miſtakes or confuſion in the writings of divers modern philoſophers. For colour may be conſidered, either as it is a quality reſiding in the body that is ſaid to be coloured, or to modify the light after ſuch or ſuch a manner; or elſe as the light it ſelf, which ſo modified, ſtrikes upon the organ of ſight, and ſo cauſes that ſenſation which we call colour: and that this latter may be looked upon as the more proper, though not the uſual acceptation of the word colour, will be made probable by divers paſſages in the enſuing part of our diſcourſe. And indeed it is the light it ſelf, which after a certain manner, either mingled with ſhades, or ſome other ways troubled, ſtrikes our eyes, that does more immediately produce that motion in the organ, upon whoſe account men ſay they ſee ſuch or ſuch a colour in the object: yet, becauſe there is in the body that is ſaid to be coloured, a certain diſpoſition of the ſuperficial particles, whereby it ſends the light reflected, or refracted, to our eyes thus and thus altered, and not otherwiſe, it may alſo in ſome ſenſe be ſaid, that colour depends upon the viſible body; and therefore we ſhall not be againſt that way of ſpeaking of colours, that is moſt uſed among the modern Naturaliſts, provided we be allowed to have recourſe, when occaſion ſhall require, to the premiſed diſtinction, and to take the more immediate cauſe of colour to be the modified light it ſelf, as it affects the ſenſory; though the diſpoſition alſo of the coloured body, as that modifies the light, may be called by that name metonymically (to borrow a ſchool-term) or efficiently, that is, in regard of its turning the light, that rebounds from it, or paſſes thorough it, into this or that particular colour.

4. I KNOW not whether I may not on this occaſion add, that colour is ſo far from being an inherent quality of the object in the ſenſe that is wont to be declared by the ſchools, or even in the ſenſe of ſome modern Atomiſts, that, if we conſider the matter more attentively, we ſhall ſee cauſe to ſuſpect, if not to conclude, that though light do more immediately affect the organ of ſight, than do the bodies that ſend it thither, yet light itſelf produces the ſenſation of a colour, but as it produces ſuch a determinate kind of local motion in ſome part of the brain; which, though it happen moſt commonly from the motion whereinto the ſlender ſtring of the retina are put, by the appulſe of light; yet if the like motion happen to be produced by any other cauſe, wherein the light concurs not at all, a man ſhall think he ſees the ſame colour. For proof of this, I might put you in mind, that it is uſual for dreaming men to think they ſee the images that appear to them in their ſleep, adorned ſome with this, and ſome with that lively colour, whilſt yet, both the curtains of their bed, and thoſe of their eyes, are cloſe drawn. And I might add the confidence with which diſtracted perſons do oftentimes, when they are awake, think they ſee black fiends in places, where there is no black object in ſight without them. But I will rather obſerve, that not only when a man receives a great ſtroke upon his eye, or a very great one upon ſome other part of his head, he is wont to ſee, as it were, flaſhes of lightning, and little vivid, but vaniſhing flames, though perhaps his eyes be ſhut: but the like apparitions may happen, when the motion proceeds not from ſomething without, but from ſomething within the body, provided the unwonted fumes that wander up and down in the head, or the propagated concuſſion of any internal part in the body, do cauſe, about the inward extremities of the optick nerve, ſuch a motion as is wont to be there produced, when the ſtroke of the light upon the retina makes us conclude, that we ſee either light or ſuch and ſuch a colour. This the moſt ingenious *Des Cartes* hath very well obſerved; but becauſe he ſeems not to have exemplified it by any unobvious or peculiar obſervation, I ſhall endeavour to illuſtrate this doctrine by a few inſtances.

5. AND firſt, I remember, that having, through God's goodneſs, been free for ſeveral years from troubleſome coughs, being afterwards, by an accident, ſuddenly caſt into a violent one, I did often when I was awaked in the night by my diſtempers, obſerve, that upon coughing ſtrongly, it would ſeem to me, that I ſaw very vivid, but immediately diſappearing flames; which I took particular notice of, becauſe of the conjecture I am now mentioning.

6. AN excellent and very diſcreet perſon, very near allied both to you and me, was relating to me, that ſome time ſince, whilſt ſhe was talking with ſome other ladies, upon a ſudden, all the objects ſhe looked upon appeared to her dyed with unuſual colours, ſome of one kind, and ſome of another, but all ſo bright and vivid, that ſhe ſhould have been as much delighted, as ſurprized with them; but that finding the apparition to continue, ſhe feared it portended ſome very great alteration as to her health: and indeed, the day after ſhe was aſſaulted with ſuch violence by hyſterical and hypocondrical diſtempers, as both made her rave for ſome days, and gave her, during that time, a baſtard palſy.

7. BEING a while ſince in a town, where the plague had made great havock, and inquiring of an ingenious man, that was ſo bold, as without much ſcruple to viſit thoſe that were ſick of it, about the odd ſymptoms of a diſeaſe that had ſwept away ſo many there; he told me, among other things, that he was able to tell divers patients, to whom he was called, before they took their beds, or had any evident ſymptoms of the plague, that they were indeed infected, upon peculiar obſervations, that being aſked, they would tell him that the neighbouring objects, and particularly his clothes, appeared to them beautified with moſt glorious colours, like thoſe of the rainbow, oftentimes ſucceeding one another: and this he affirmed to be one of the moſt uſual, as well as the moſt early ſymptoms, by which this odd peſtilence diſcloſed it ſelf. And when

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I aſked how long the patients were wont to be thus affected, he anſwered, that it was moſt commonly for about a day; and when I further inquired whether or no vomits, which in that peſtilence were uſually given, did not remove this ſymptom, (for ſome uſed the taking of a vomit, when they came aſhore, to cure themſelves of the obſtinate and troubleſome giddineſs cauſed by the motion of the ſhip) he replied, that generally, upon the evacuation made by the vomit, that ſtrange apparition of colours ceaſed, though the other ſymptoms were not ſo ſoon abated; yet he added (to take notice of that upon the by, becauſe the obſervation may perchance do good) that an excellent phyſician, in whoſe company he was wont to viſit the ſick, did give to almoſt all thoſe to whom he was called, in the beginning, before nature was much weakened, a pretty odd vomit, conſiſting of eight or ten drams of infuſion of *Crocus Metallorum*, and about half a dram, or much more, of white vitriol, with ſuch ſucceſs, that ſcarce one of ten to whom it was ſeaſonably adminiſtred, miſcarried.

8. BUT to return to the conſideration of colours: As an apparition of them may be produced by motions from within, without the aſſiſtance of an outward object; ſo I have obſerved, that it is ſometimes poſſible that the colour that would otherwiſe be produced by an outward object, may be changed by ſome motion, or new texture already produced in the ſenſory, as long as that unuſual motion, or new diſpoſition laſts; for I have divers times tried, that after I have through a teleſcope looked upon the ſun, though thorough a thick, red, or blue glaſs, to make its ſplendor ſupportable to the eye, the impreſſion upon the retina would be not only ſo vivid, but ſo permanent, that if afterwards I turned my eye towards a flame, it would appear to me of a colour very differing from its uſual one. And if I did divers times ſucceſſively ſhut and open the ſame eye, I ſhould ſee the adventitious colour (if I may ſo call it) changed or impaired by degrees, till at length (for this unuſual motion of the eye would not preſently ceaſe) the flame would appear to me of the ſame hue that it did to other beholders. A not unlike effect I found by looking upon the moon, when ſhe was near full, thorough an excellent teleſcope, without coloured glaſs to ſcreen my eye with: but that which I deſire may be taken notice of, becauſe we may elſewhere have occaſion to reflect upon it, and becauſe it ſeems not agreeable to what Anatomiſts and optical writers deliver, touching the relation of the two eyes to each other, is this circumſtance, that though my right eye, with which I looked thorough the teleſcope, were thus affected by the over-ſtrong impreſſion of the light, yet when the flame of a candle, or ſome other bright object appeared to me of a very unuſual colour, whilſt looked upon with the diſcompoſed eye, or (though not ſo notably) with both eyes at once; yet if I ſhut that eye, and looked upon the ſame object with the other, it would appear with no other than its uſual colour, though if I again opened, and made uſe of the dazled eye, the vivid adventitious colour would again appear. And on this occaſion I muſt not pretermit an obſervation which may perſuade us, that an overvehement ſtroke upon the ſenſory, eſpecially if it be naturally of a weak conſtitution, may make a more laſting impreſſion than one would imagine; which impreſſion may in ſome caſes, as it were, mingle with, and vitiate the action of vivid objects for a long time after.

FOR I know a lady of unqueſtionable veracity, who having lately, by a deſperate fall, received ſeveral hurts, and particularly a conſiderable one upon a part of her face near her eye, had her ſight ſo troubled and diſordered, that, as ſhe hath more than once related to me, not only when the next morning one of her ſervants came to her bed-ſide, to ask how ſhe did, his clothes appeared adorned with ſuch variety of dazling colours, that ſhe was fain preſently to command him to withdraw, but the images in her hangings did, for many days after, appear to her, if the room were not extraordinarily darkened, embelliſhed with ſeveral offenſively vivid colours, which no body elſe could ſee in them. And when I inquired whether or no white objects did not appear to her adorned with more luminous colours than others, and whether ſhe ſaw not ſome which ſhe could not well deſcribe to any, whoſe eyes had never been diſtempered, ſhe anſwered me, that ſometimes ſhe thought ſhe ſaw colours ſo new and glorious, that they were of a peculiar kind, and ſuch as ſhe could not deſcribe by their likeneſs to any ſhe had beheld either before or ſince; and that white objects did ſo much diſorder her ſight, that if, ſeveral days after her fall, ſhe looked upon the inſide of a book, ſhe fancied ſhe ſaw there colours like thoſe of the rainbow: and even when ſhe thought her ſelf pretty well recovered, and made bold to leave her chamber, the coming into a place where the walls and ceiling were whited over, made thoſe objects appear to her cloathed with ſuch glorious and dazling colours, as much offended her ſight, and made her repent her venturouſneſs. And ſhe added, that this diſtemper of her eyes laſted not leſs than five or ſix weeks, though ſince that, ſhe hath been able to read and write much without finding the leaſt inconvenience in doing ſo. I would gladly have known, whether if ſhe had ſhut the injured eye, the phænomena would have been the ſame, when ſhe employed only the other; but I heard not of this accident early enough to ſatisfy that inquiry.

9. WHEREFORE, I ſhall now add, that ſome years before, a perſon exceedingly eminent for his profound ſkill in almoſt all kinds of philological learning, coming to adviſe with me about a diſtemper in his eyes, told me, among other circumſtances of it, that having upon a time looked too fixedly upon the ſun, thorough a teleſcope, without any coloured glaſs, to take off from the dazling ſplendor of the object, the exceſs of light did ſo ſtrongly affect his eye, that ever ſince, when he turns it towards a window, or any white object, he fancies he ſeeth a globe of light, of about the bigneſs the

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ſun then appeared of to him, to paſs before his eyes: and having inquired of him, how long he had been troubled with this indiſpoſition, he replied, that it was already nine or ten years ſince the accident, that occaſioned it, firſt befel him.

10. I COULD here ſubjoin, *Pyrophilus*, ſome memorable relations that I have met with in the account given us by the experienced *Epiphanius Ferdinandus*, of the ſymptoms he obſerved to be incident to thoſe that are bitten with the Tarantula; by which (relations) I could probably ſhew, that without any change in the object, a change in the inſtruments of viſion may for a great while make ſome colours appear charming, and make others provoking, and both to a high degree, though neither of them produced any ſuch effects before. Theſe things, I ſay, I could here ſubjoin in confirmation of what I have been ſaying, to ſhew that the diſpoſition of the organ is of great importance in the dijudications we make of colours, were it not that theſe ſtrange ſtories belonging more properly to another diſcourſe, I had rather (contenting my ſelf to have given you an intimation of them here) that you ſhould meet with them fully delivered there.

CHAP. III.

1. BUT, *Pyrophilus*, I would not, by all that I have hitherto diſcourſed, be thought to have forgotten the diſtinction (of colour) that I mentioned to you about the beginning of the third ſection of the former chapter; and therefore, after all I have ſaid of colour, as it is modified light, and immediately affects the ſenſory, I ſhall now remind you, that I did not deny, but that colour might in ſome ſenſe be conſidered as a quality reſiding in the body that is ſaid to be coloured; and indeed the greateſt part of the following experiments refer to colour principally under that notion, for there is in the bodies we call coloured, and chiefly in their ſuperficial parts, a certain diſpoſition, whereby they do ſo trouble the light that comes from them to our eye, as that it there makes that diſtinct impreſſion, upon whoſe account we ſay, that the ſeen body is either white or black, or red or yellow, or of any one determinate colour. But becauſe we ſhall (God permitting) by the experiments that are to follow ſome pages hence, more fully and particularly ſhew, that the changes, and conſequently in divers places the production and the appearance of colours, depends upon the continuing or altered texture of the object; we ſhall in this place intimate (and that too but as by the way) two or three things about this matter.

2. AND firſt, it is not without ſome reaſon, that I aſcribe colour (in the ſenſe formerly explained) chiefly to the ſuperficial parts of bodies; for not to queſtion how much opacous corpuſcles may abound even in thoſe bodies we call diaphanous, it ſeems plain that of opacous bodies we do indeed ſee little elſe than the ſuperficies. For if we found the beams of light that rebound from the object to the eye, to pierce deep into the coloured body, we ſhould not judge it opacous, but either tranſlucid, or at leaſt ſemi-diaphanous: and though the ſchools ſeem to teach us that colour is a penetrative quality, that reaches to the innermoſt parts of the object, as if a piece of ſealing-wax be broken into never ſo many pieces, the internal fragments will be as red as the external ſurface did appear; yet that is but a particular example, that will not overthrow the reaſon lately offered, eſpecially ſince I can alledge other examples of a contrary import, and two or three negative inſtances are ſufficient to overthrow the generality of a poſitive rule, eſpecially if that be built but upon one or a few examples. Not (then) to mention cherries, plums, and I know not how many other bodies, wherein the ſkin is of one colour, and what it hides of another, I ſhall name a couple of inſtances drawn from the colours of durable bodies that are thought far more homogeneous, and have not parts that are either organical, or of a nature approaching thereunto.

3. To give you the firſt inſtance, I ſhall need but to remind you of what I told you a little after the beginning of this eſſay, touching the blue and red and yellow, that may be produced upon a piece of tempered ſteel: for theſe colours, though they be very vivid, yet if you break the ſteel they adorn, they will appear to be but ſuperficial; not only the innermoſt parts of the metal, but thoſe that are within a hair's breadth of the ſuperficies, having not any of theſe colours, but retaining that of the ſteel it ſelf. Beſides that, we may as well confirm this obſervation, as ſome other particulars we elſewhere deliver concerning colours, by the following experiment which we purpoſely made.

4. WE took a good quantity of clean lead, and melted it with a ſtrong fire, and then immediately pouring it out into a clean veſſel of a convenient ſhape and matter, (we uſed one of iron, that the great and ſudden heat might not injure it) and then carefully and nimbly taking off the ſcum that floated on the top, we perceived, as we expected, the ſmooth and gloſſy ſurface of the melted matter to be adorned with a very glorious colour, which being as tranſitory as delightful, did almoſt immediately give place to another vivid colour, and that was as quickly ſucceeded by a third, and this as it were chaſed away by a fourth; and ſo theſe wonderfully vivid colours ſucceſſively appeared and vaniſhed, (yet the ſame now and then appearing the ſecond time) till the metal ceaſing to be hot enough to afford any longer this pleaſing ſpectacle, the colours that chanced to adorn the ſurface, when the lead thus began to cool, remained upon it; but were ſo ſuperficial, that how little ſoever we ſcraped off the ſurface of the lead, we did in ſuch places ſcrape off all the colour, and diſcover only that which is natural to the metal it ſelf; which receiving its adventitious colours, only when the heat was very intenſe, and in that part which was expoſed to the com-

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paratively very cold air, (which by other experiments ſeems to abound with ſubtile ſaline parts, perhaps not uncapable of working upon lead ſo diſpoſed :) theſe things, I ſay, together with my obſerving that whatever parts of the ſo ſtrongly melted lead were expoſed a while to the air, turned into a kind of ſcum or litharge, how bright and clean ſoever they appeared before, ſuggeſted to me ſome thoughts or ravings, which I have not now time to acquaint you with. One that did not know me, *Pyrophilus*, would perchance think I endeavoured to impoſe upon you by relating this experiment, which I have ſeveral times tried; but the reaſon why the phænomena mentioned have not been taken notice of, may be, that unleſs lead be brought to a much higher degree of fuſion or fluidity than is uſual, or than is indeed requiſite to make it melt, the phænomena I mentioned will ſcarce at all diſcloſe themſelves; and we have alſo obſerved, that this ſucceſſive appearing and vaniſhing of vivid colours was wont to be impaired or determined whilſt the metal expoſed to the air remained yet hotter than one would readily ſuſpect. And one thing I muſt further note, of which I leave you to ſearch after the reaſon, namely, that the ſame colours did not always and regularly ſucceed one another, as is uſual in ſteel, but in the diverſified order mentioned in this following note, which I was ſcarce able to write down, the ſucceſſion of the colours was ſo very quick: whether that proceeded from the differing degrees of heat in the lead expoſed to the cool air, or from ſome other reaſon, I leave you to examine.

[*Blue, yellow, purple, blue; green, purple, blue, yellow, red; purple, blue, yellow and blue, yellow, blue, purple, green mixt, yellow, red, blue, green, yellow, red, purple, green.*]

5. THE Atomiſts of old, and ſome learned men of late, have attempted to explicate the variety of colours is opacous bodies from the various figures of their ſuperficial parts; the attempt is ingenious, and the doctrine ſeems partly true: but I confeſs I think there are divers other things that muſt be taken in as concurrent to produce thoſe differing forms of aſperity, whereon the colours of opacous bodies ſeem to depend. To declare this a little, we muſt aſſume, that the ſurfaces of all ſuch bodies, how ſmooth or polite ſoever they may appear to our dull ſight and touch, are exactly ſmooth only in a popular, or at moſt in a phyſical ſenſe, but not in a ſtrict and rigid ſenſe.

6. THIS, excellent microſcopes ſhew us in many bodies, that ſeem ſmooth to our naked eyes; and this not only as to the little hillocks or protuberances that ſwell above that which may be conceived to be the plane or level of the conſidered ſurface; for it is obvious enough to thoſe that are any thing converſant with ſuch glaſſes: but as to numerous depreſſions beneath that level, of which ſort of cavities, by the help of a microſcope, which the greateſt artificer that makes them, judges to be the greateſt magnifying glaſs in *Europe*, except one that equals it, we have on the ſurface of a thin piece of cork that appeared ſmooth to the eye, obſerved about ſixty in a row, within the length of leſs than a 31 and 32^{d} part of an inch, (for the glaſs takes in no longer a ſpace at one view;) and theſe cavities (which made that little piece of cork almoſt like an empty honey-comb) were not only very diſtinct, and figured like one another, but of a conſiderable bigneſs, and a ſcarce credible depth; inſomuch that their diſtinct ſhadows as well as ſides were plainly diſcerned and eaſy to be reckoned, and might have been well diſtinguiſhed, though they had been ten times leſſer than they were. Which I thought it not amiſs to mention to you, *Pyrophilus*, upon the by, that you may thence make ſome eſtimate, what a ſtrange inequality, and what a multitude of little ſhades there may really be, in a ſcarce ſenſible part of the phyſical ſuperficies, though the naked eye ſees no ſuch matter. And as excellent microſcopes ſhew us this ruggedneſs in many bodies that paſs for ſmooth, ſo there are divers experiments, though we muſt not now ſtay to urge them, which ſeem to perſuade us of the ſame thing, as to the reſt of ſuch bodies as we are now treating of; ſo, that there is no ſenſible part of an opacous body, that may not be conceived to be made up of a multitude of ſingly inſenſible corpuſcles. But in the giving theſe ſurfaces that diſpoſition, which makes them alter the light that reflects thence to the eye after the manner requiſite to make the object appear green, blue, *&c.* the figures of theſe particles have a great, but not the only ſtroke. It is true indeed, that the protuberant particles may be of very great variety of figures, ſpherical, elliptical, conical, cylindrical, polyedrical, and ſome very irregular; and that according to the nature of theſe, and the ſituation of the lucid body, the light muſt be variouſly affected, after one manner from ſurfaces (I now ſpeak of phyſical ſurfaces) conſiſting of ſpherical, and in another from thoſe that are made up of conical or cylindrical corpuſcles; ſome being fitted to reflect more of the incident beams of light, others leſs, and ſome towards one part, others towards another. But beſides this difference of ſhape, there may be divers other things that may eminently concur to vary the forms of aſperity that colours ſo much depend on. For, willingly allowing the figure of the particles in the firſt place, I conſider ſecondly, that the ſuperficial corpuſcles, if I may ſo call them, may be bigger in one body, and leſs in another, and conſequently fitted to allay the light falling on them with greater ſhades. Next, the protuberant particles may be ſet more or leſs cloſe together, that is, there may be a greater or a ſmaller number of them within the compaſs of one, than within the compaſs of another ſmall part of the ſurface of the ſame extent; and how much theſe qualities may ſerve to produce colour, may be ſomewhat gueſſed at, by that which happens in the agitation of water: for if the bubbles that are thereby made be great, and but few, the water will ſcarce acquire a ſenſible colour; but if it be reduced to a froth, conſiſting of bubbles, which being

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being very minute and contiguous to each other, are a multitude of them crouded into a narrow room, the water (turned to froth) does then exhibit a very manifeſt white colour, to which theſe laſt named conditions of the bubbles do, as well as their convex figure, contribute; and that for reaſons to be mentioned anon. Beſides, it is not neceſſary that the ſuperficial particles that exhibit one colour ſhould be all of them round, or all conical, or all of any one ſhape; but corpuſcles of differing figures may be mingled on the ſurface of the opacous body, as when the corpuſcles that make a blue colour, and thoſe that make a yellow, come to be accurately and ſkilfully mix'd, they make up a green; which, though it ſeem one ſimple colour, yet, in this caſe, appears to be made by corpuſcles of very differing kinds, duly commix'd. Moreover, the figure and bigneſs of the little depreſſions, cavities, furrows, or pores intercepted betwixt theſe protuberant corpuſcles, are as well to be conſidered as the ſizes and ſhapes of the corpuſcles themſelves: for we may conceive the phyſical ſuperficies of a body, where (as we ſaid) its colour does, as it were, reſide, to be cut tranſverſly by a mathematical plane, which you know is conceiv'd to be without any depth or thickneſs at all; and then, as ſome parts of the phyſical ſuperficies will be protuberant, or ſwell above this laſt plane, ſo others may be depreſſed beneath it, as (to explain my ſelf by a groſs compariſon) in divers places of the ſurface of the earth, there are not only neighbouring hills, trees, *&c.* that are rais'd above the horizontal level of the valley, but rivers, wells, pits and other cavities that are depreſſed beneath it. And that ſuch protuberant and concave parts of a ſurface may remit the light ſo differingly, as much to vary a colour, ſome examples, and other things that we ſhall hereafter have occaſion to take notice of in this tract, will ſufficiently declare; till when, it may ſuffice to put you in mind, that of two flat ſides of the ſame piece of, for example, red marble, the one being diligently poliſhed, and the other left to its former roughneſs, the differing degrees or ſorts of aſperity, for the ſide that is ſmooth to the touch wants not its roughneſs, will ſo diverſify the light reflected from the ſeveral planes to the eye, that a painter would employ two differing colours to repreſent them.

See the Diſcourſe of the nature of whiteneſs and blackneſs.

7. And I hope, *Pyrophilus*, you will not think it ſtrange or impertinent, that I employ, in divers paſſages of theſe papers, examples drawn from bodies and ſhadows far more groſs than thoſe minute protuberances and ſhady pores on which, in moſt caſes, the colour of a body, as it is an inherent quality or diſpoſition of its ſurface, ſeems to depend. For ſometimes I employ ſuch examples, rather to declare my meaning, than prove my conjecture; things, whom their ſmallneſs makes inſenſible, being better repreſented to the imagination by ſuch familiar objects, as being like them enough in other reſpects, are of a viſible bulk. And next, though the beams of light are ſuch ſubtile bodies, that in reſpect of them, even ſurfaces that are ſenſibly ſmooth, are not exactly ſo, have their own degree of roughneſs, conſiſting of little protuberances and depreſſions; and though conſequently ſuch inequalities may ſuffice to give bodies differing colours, as we ſee in marble that appears white or black, or red or blue, even when the moſt carefully poliſhed; yet it is plain, by the late inſtance of red marble, and many others, that even bigger protuberances and greater ſhades may likewiſe ſo diverſify the roughneſs of a body's ſuperficies, as manifeſtly to concur to the varying of its colour, whereby ſuch examples appear to be proper enough to be employed in ſuch a ſubject as we have now in hand. And having hinted thus much on this occaſion, I now proceed.

8. The ſituation alſo of the ſuperficial particles is conſiderable, which I diſtinguiſh into the poſture of the ſingle corpuſcles, in reſpect of the light, and of the eye, and the order of them in reference alſo to one another; for a body may otherwiſe reflect the light, when its ſuperficial particles are more erected upon the plane, that may be conceived to paſs along their baſis, and when the points or extremes of ſuch particles are obverted to the eye, than when thoſe particles are ſo inclined, that their ſides are in great part diſcernable; as the colour of pluſh or velvet will appear varied to you, if you carefully ſtroak part of it one way, and part of it another; the poſture of the particular thrids, in reference to the light, or the eye, becoming thereby different. And you may obſerve in a field of ripe corn blown upon by the wind, that there will appear as it were waves of a colour (at leaſt gradually) differing from that of the reſt of the field; the wind, by depreſſing ſome of the ears, and not at the ſame time others, making the one reflect more from the lateral and ſtrawy parts than do the reſt. And ſo, when dogs are ſo angry as to erect the hairs upon their necks, and upon ſome other parts of their bodies, thoſe parts ſeem to acquire a colour varied from that which the ſame hairs made, when in their uſual poſture they did far more ſtoop. And that the order wherein the ſuperficial corpuſcles are rang'd, is not to be neglected, we may gueſs by turning of water into froth, the beating of glaſs, and the ſcraping of horns, in which caſes the corpuſcles that were before ſo marſhalled as to be perſpicuous, do by the troubling of that order become diſpoſed to terminate and reflect more light, and thereby to appear whitiſh. And there are other ways in which the order of the protuberant parts, in reference to the eye, may much contribute to the appearing of a particular colour; for I have often obſerved, that when peas are planted, or ſet in parallel lines, and are ſhot up about half a foot above the ſurface of the ground, by looking on the field or plot of ground from that part towards which the parallel lines tended, the greater part of the ground by far, would appear of its own dirty colour; but if I looked upon it tranſverſly, the plot would appear very green, the upper parts of the peas hindering the intercepted parts of the ground, which, as I ſaid, retained their

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wonted colour from being discovered by the Eye. And I know not, *Pyrophilus*, whether I might not add, that even the motion of the small parts of a visible object may in some cases contribute, though it be not so easy to say how, to the producing, or the varying of a colour: for I have several times made a liquor which, when it has well settled in a close phial, is transparent and colourless; but as soon as the glass is unstopped, begins to fly away very plentifully in a white and opacous fume. And there are other bodies, whose fumes, when they fill a receiver, would make one suspect it contains milk; and yet when these fumes settle into a liquor, that liquor is not white, but transparent; and such white fumes I have seen afforded by unstopping a liquor I know, which yet is it self diaphanous and red: nor are these the only instances of this kind, that our trials can supply us with. And if the superficial corpuscles be of the grosser sort, and be so framed, that their differing sides or faces may exhibit differing colours, then the motion or rest of those corpuscles may be considerable, as to the colour of the superficies they compose, upon this account, that sometimes more, sometimes fewer of the sides disposed to exhibit such a colour may by this means become or continue more obverted to the eye than the rest, and compose a physical surface, that will be more or less sensibly interrupted. As, to explain my meaning, by proposing a gross example, I remember, that in some sorts of leafy plants thick set by one another, the two sides of whose leaves were of somewhat differing colours, there would be a notable disparity as to colour, if you looked upon them both, when the leaves, being at rest, had their upper and commonly exposed sides obverted to the eye, and when a breath of wind passing thorough them, made great numbers of the usually hidden sides of the leaves become conspicuous. And though the little bodies we were lately speaking of, may singly and apart seem almost colourless; yet when many of them are placed by one another, so near that the eye does not easily discern an interruption, within a sensible space, they may exhibit a colour: as we see, that though the slenderest thrid of dyed silk does whilst look'd on single, seem almost quite devoid of redness, (for instance) yet when numbers of these thrids are brought together into one skein, their colour becomes notorious.

9. BUT the same occasion that invited me to say what I have mentioned concerning the leaves of trees, invites me also to give you some account of what happens in changeable taffaties, where we see differing colours, as it were, emerge and vanish upon the ruffling of the same piece of silk; as I have divers times with pleasure observed, by the help of such a microscope, as though it do not very much magnify the object, has in recompence this great conveniency, that you may easily, as fast as you please, remove it from one part to another of a large object, of which the glass taking a great part at once, you may thereby presently survey the whole. Now by the help of such a microscope I could easily (as I began to say) discern, that in a piece of changeable taffaty (that appeared, for instance, sometimes red, and sometimes green) the stuff was composed of red thrids and green, passing under and over each other, and crossing one another in almost innumerable points: and if I looked through the glass upon any considerable portion of the stuff, that (for example sake) to the naked eye appeared to be red, I could plainly see, that in that position, the red thrids were conspicuous, and reflected a vivid light. And though I could also perceive, that there were green ones, yet by reason of their disadvantageous position in the physical surface of the taffaty, they were in part hid by the more protuberant thrids of the other colour: and for the same cause, the reflection from as much of the green as was discovered, was comparatively but dim and faint. And if, on the contrary, I looked through the microscope upon any part that appeared green, I could plainly see that the red thrids were less fully exposed to the eye, and obscured by the green ones, which therefore made up the predominant colour. And by observing the texture of the silken stuff, I could easily so expose the thrids either of the one colour or of the other, to my eye, as at pleasure to exhibit an apparition of red or green, or make those colours succeed one another: so that, when I observed their succession by the help of the glass, I could mark how the predominant colour did as it were start out, when the thrids that exhibited it came to be advantageously placed; and by making little folds in the stuff after a certain manner, the sides that met and terminated in those folds, would appear to the naked eye, one of them red, and the other green. When thrids of more than two differing colours chance to be interwoven, the resulting changeableness of the taffaty may be also somewhat different. But I chuse to give an instance in the stuff I have been speaking of, because the mixture being more simple, the way whereby the changeableness is produced, may be the more easily apprehended: and though reason alone might readily enough lead a considering man to guess at the explication, in case he knew how changeable taffaties are made; yet I thought it not impertinent to mention it, because both scholars and gentlemen are wont to look upon the inquiry into manufactures, as a mechanick employment, and consequently below them; and because also with such a microscope as I have been mentioning, the discovery is as well pleasant as satisfactory, and may afford hints of the solution of other phænomena of colours. And it were not amiss, that some diligent inquiry were made, whether the microscope would give us an account of the variableness of colour, that is so conspicuous and so delightful in mother of pearl, in opals, and some other resembling bodies. For though I remember I did formerly attempt something of that kind (fruitlesly enough) upon mother of pearl, yet not having then the advantage of my best microscope, nor some conveniencies that might have been wished, I leave it to you, who have better eyes, to

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to try what you can do further; ſince it will be ſome diſcovery to find, that in this caſe the beſt eyes and microſcopes themſelves can make none.

10. I CONFESS, *Pyrophilus*, that a great part of what I have delivered, (or propoſed rather) concerning the differing forms of aſperity in bodies, by which differences, the incident light either comes to be reflected with more or leſs of ſhade, and with that ſhade more or leſs interrupted, or elſe happens to be alſo otherwiſe modified or troubled, is but conjectural. But I am not ſure, that if it were not for the dulneſs of our ſenſes, either theſe or ſome other notions of kin to them, might be better countenanced; for I am apt to ſuſpect, that if we were ſharp-ſighted enough, or had ſuch perfect microſcopes, as I fear are more to be wiſhed than hoped for, our promoted ſenſe might diſcern in the phyſical ſurfaces of bodies, both a great many latent ruggedneſſes, and the particular ſizes, ſhapes, and ſituations of the extremely little bodies that cauſe them, and perhaps might perceive among other varieties that we now can but imagine, how thoſe little protuberances and cavities do interrupt and dilate the light, by mingling with it a multitude of little and ſingly undiſcernable ſhades, though ſome of them more, and ſome of them leſs minute, ſome leſs, and ſome more numerous, according to the nature and degree of the particular colour we attribute to the viſible object. As we ſee, that in the moon we can with excellent teleſcopes diſcern many hills and valleys, and as it were pits and other parts, whereof ſome are more, and ſome leſs vividly illuſtrated, and others have a fainter, others a deeper ſhade, though the naked eye can diſcern no ſuch matter in that planet. And with an excellent microſcope, where the naked eye did ſee but a green pouder, the aſſiſted eye, as we noted above, could diſcern particular granules, ſome of them of a blue, and ſome of them of a yellow colour, which corpuſcles we had beforehand cauſed to be exquiſitely mixed to compound the green.

11. AND, *Pyrophilus*, that you may not think me altogether extravagant in what I have ſaid of the poſſibility (for I ſpeak of no more) of diſcerning the differing forms of aſperity in the ſurfaces of bodies of ſeveral colours, I'll here ſet down a memorable particular that chanced to come to my knowledge, ſince I writ a good part of this eſſay; and it is this. Meeting caſually the other day with the deſervedly famous * Dr. *J. Finch*, extraordinary anatomiſt to that great patron of the Virtuoſi, the now Great Duke of *Tuſcany*, and inquiring of this ingenious perſon, what might be the chief rarity he had ſeen in his late return out of *Italy* into *England*, he told me, it was a man at *Maeſtricht* in the *Low-Countries*, who at certain times can diſcern and diſtinguiſh colours by the touch with his fingers. You will eaſily conclude, that this is far more ſtrange than what I propoſed but as not impoſſible; ſince the ſenſe of the retina ſeeming to be much more tender and quick than that of thoſe groſſer filaments, nerves or membranes of our fingers, wherewith we uſe to handle groſs and hard bodies, it ſeems ſcarce credible, that any accuſtomance, or diet, or peculiarity of conſtitution, ſhould enable a man to diſtinguiſh, with ſuch groſs and unſuitable organs, ſuch nice and ſubtile differences of thoſe of the forms of aſperity, that belong to differing colours, to receive whoſe languid and delicate impreſſions by the intervention of light, nature ſeems to have appointed and contexed into the retina the tender and delicate pith of the optick nerve. Wherefore I confeſs, I propoſed divers ſcruples; and particularly whether the doctor had taken care to bind a napkin or handkerchief over his eyes ſo carefully, as to be ſure he could make no uſe of his ſight, though he had but counterfeited the want of it; to which I added divers other queſtions, to ſatisfy my ſelf, whether there were any likelihood of colluſion or other tricks. But I found that the judicious doctor having gone far out of his way, purpoſely to ſatisfy himſelf and his learned prince about this wonder, had been very watchful and circumſpect to keep himſelf from being impoſed upon. And that he might not through any miſtake in point of memory miſinform me, he did me the favour, at my requeſt, to look out the notes he had written for his own and his prince's information, the ſum of which memorials, as far as we ſhall mention them here, was this, that the doctor having been informed at *Utrecht*, that there lived one at ſome miles diſtance from *Maeſtricht*, who could diſtinguiſh colours by the touch; when he came to the laſt named town, he ſent a meſſenger for him, and having examined him, was told upon inquiry theſe particulars.

THAT the man's name was *John Vermaaſen*, at that time about 33 years of age; that when he was but two years old, he had the ſmall pox, which rendered him abſolutely blind; that at this preſent he is an organiſt, and ſerves that office in a publick choir.

THAT the doctor diſcourſing with him over night, the blind man affirmed, that he could diſtinguiſh colours by the touch, but that he could not do it, unleſs he were faſting; any quantity of drink taking from him that exquiſiteneſs of touch, which is requiſite to ſo nice a ſenſation.

THAT hereupon the doctor provided againſt the next morning ſeven pieces of ribbon, of theſe ſeven colours, black, white, red, blue, green, yellow, and grey; but as for mingled colours, this *Vermaaſen* would not undertake to diſcern them, though if offered, he would tell that they were mixed.

THAT to diſcern the colour of the ribbon, he places it betwixt the thumb and the forefinger, but his moſt exquiſite perception was in his thumb, and much better in the right thumb than in the left.

THAT after the blind man had four or five times told the doctor the ſeveral colours, (though blinded with a napkin for fear he might have ſome ſight) the doctor found he was twice miſtaken, for he called the white black, and the red blue; but ſtill, he, before his error,

* *Since, for his eminent qualities and loyalty, graced by his Majeſty with the honour of knighthood.*

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would lay them by in pairs, ſaying, that though he could eaſily diſtinguiſh them from all others, yet thoſe two pairs were not eaſily diſtinguiſhed amongſt themſelves. Whereupon the doctor deſired to be told by him what kind of diſcrimination he had of colours by his touch, to which he gave a reply, for whoſe ſake chiefly I inſert all this narrative in this place; namely, that all the difference was more or leſs aſperity, for ſays he, (I give you the doctor's own words) black feels as if you were feeling needles points, or ſome harſh ſand, and red feels very ſmooth.

THAT the doctor having deſired him to tell in order the difference of colours to his touch, he did as follows.

BLACK and white are the moſt aſperous or unequal of all colours, and ſo like, that 'tis very hard to diſtinguiſh them; but black is the moſt rough of the two: green is next in aſperity, grey next to green in aſperity, yellow is the fifth in degree of aſperity; red and blue are ſo like, that they are as hard to diſtinguiſh as black and white; but red is ſomewhat more aſperous than blue, ſo that red has the ſixth place, and blue the ſeventh in aſperity.

12. To theſe informations the obliging doctor was pleaſed to add the welcome preſent of three of thoſe very pieces of ribbon, whoſe colours in his preſence the blind man had diſtinguiſhed, pronouncing the one grey, the other red, and the third green; which I keep by me as rarities, and the rather, becauſe he feared the reſt were miſcarried.

13. BEFORE I ſaw the notes that afforded me the precedent narrative, I confeſs I ſuſpected this man might have thus diſcriminated colours rather by the ſmell than by the touch; for ſome of the ingredients imployed by dyers to colour things, have ſcents, that are not ſo languid, nor ſo near of kin: but that I thought it not impoſſible that a very critical noſe might diſtinguiſh them, and this I the rather ſuſpected, becauſe he required, that the ribbons, whoſe colours he was to name, ſhould be offered him faſting in the morning; for I have obſerved in ſetting dogs, that the feeding of them (eſpecially with ſome ſorts of aliments) does very much impair the exquiſite ſcent of their noſes. And though ſome of the foregoing particulars would have prevented that conjecture, yet I confeſs to you *(Pyrophilus)* that I would gladly have had the opportunity of examining this man myſelf, and of queſtioning him about divers particulars which I do not find to have been yet thought upon. And though it be not incredible to me, that ſince the liquors that dyers employ to tinge, are qualified to do ſo by multitudes of little corpuſcles of the pigment or dying ſtuff, which are diſſolved and extracted by the liquor, and ſwim to and fro in it, thoſe corpuſcles of colour (as the Atomiſts call them) inſinuating themſelves into, and filling all the pores of the body to be dyed, may aſperate its ſuperficies more or leſs according to the bigneſs and texture of the corpuſcles of the pigment; yet I can ſcarce believe, that our blind man could diſtinguiſh all the colours he did, meerly by the ribbons having more or leſs of aſperity; ſo that I cannot but think, notwithſtanding this hiſtory, that the blind man diſtinguiſhed colours not only by the degrees of aſperity in the bodies offered to him, but by forms of it, though this (latter) would perhaps have been very difficult for him to make an intelligible mention of, becauſe thoſe minute diſparities having not been taken notice of by men for want of touch as exquiſite as our blind man's, are things he could not have intelligibly expreſſed; which will eaſily ſeem probable, if you conſider, that under the name of ſharp, and ſweet, and ſour, there are abundance of, as it were, immediate peculiar reliſhes or taſtes in differing ſorts of wine, which, though critical and experienced palates can eaſily diſcern themſelves, cannot make them be underſtood by others; ſuch minute differences not having hitherto any diſtinct names aſſigned them. And it ſeems that there was ſomething in the forms of aſperity that was requiſite to the diſtinction of colours, beſides the degree of it, ſince he found it ſo difficult to diſtinguiſh black and white from one another, though not from other colours. For I might urge, that he ſeems not conſonant to himſelf about the red, which, as you have ſeen in one place, he repreſents as ſomewhat more aſperous than the blue; and in another, very ſmooth: but becauſe he ſpeaks of this ſmoothneſs in that place, where he mentions the roughneſs of black, we may favourably preſume that he might mean but a comparative ſmoothneſs; and therefore I ſhall not inſiſt on this, but rather countenance my conjecture by this, that he found it ſo difficult, not only to diſcriminate red and blue, (though the firſt of our promiſcuous experiments will inform you, that the red reflects by great odds more light than the other) but alſo to diſtinguiſh black and white from one another, though not from other colours. And indeed, though in the ribbons that were offered him, they might be almoſt equally rough, yet in ſuch ſlender corpuſcles, as thoſe of colour, there may eaſily enough be conceived, not only a greater cloſeneſs of parts, or elſe paucity of protuberant corpuſcles, and the little extant particles may be otherwiſe figured, and ranged in the white than in the black, but the cavities may be much deeper in the one than the other.

14. AND perhaps, *(Pyrophilus)* it may prove ſome illuſtration of what I mean, and help you to conceive how this may be, if I repreſent, that where the particles are ſo exceeding ſlender, we may allow the parts expoſed to the ſight and touch to be a little convex in compariſon of the erected particles of black bodies, as if there were wires I know not how many times ſlenderer than a hair: whether you ſuppoſe them to be figured like needles, or cylindrically, like the hairs of a bruſh, with hemiſpherical (or at leaſt convex) tops, they will be ſo very ſlender, and conſequently the points both of the one ſort and the other ſo very ſharp, that even an exquiſite touch will be able to diſtinguiſh no greater difference between them, than that which our

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blind man allowed, when comparing black and white bodies, he ſaid, that the latter was the leſs rough of the two. Nor is every kind of roughneſs, though ſenſible enough, inconſiſtent with whiteneſs, there being caſes, wherein the phyſical ſuperficies of a body is made by the ſame operation both rough and white; as when the level ſurface of clear water being by agitation aſperated with a multitude of unequal bubbles, does thereby acquire a whiteneſs; and as a ſmooth piece of glaſs, by being ſcratched with a diamond, does in the aſperated part of its ſurface diſcloſe the ſame colour. But more (perchance) of this elſewhere.

15. And therefore, we ſhall here paſs by the queſtion, whether any thing might be conſidered about the opacity of the corpuſcles of black pigments, and the comparative diaphaneity of thoſe of many white bodies, applied to our preſent caſe; and proceed to repreſent, that the newly mentioned exiguity and ſhape of the extant particles being ſuppoſed, it will then be conſiderable what we lately but hinted, (and therefore muſt now ſomewhat explain) that the depth of the little cavities, intercepted between the extant particles, without being ſo much greater in black bodies than in white ones, as to be perceptibly ſo to the groſs organs of touch, may be very much greater in reference to their diſpoſition of reflecting the imaginary ſubtile beams of light. For in black bodies, thoſe little intercepted cavities, and other depreſſions, may be ſo figured, ſo narrow and ſo deep, that the incident beams of light, which the more extant parts of the phyſical ſuperficies are diſpoſed to reflect inwards, may be detained there, and prove unable to emerge; whilſt, in a white body, the ſlender particles may not only by their figure be fitted to reflect the light copiouſly outwards, but the intercepted cavities being not deep, nor perhaps very narrow, the bottoms of them may be ſo conſtituted, as to be fit to reflect outwards much of the light that falls even upon them; as you may poſſibly better apprehend, when we ſhall come to treat of whiteneſs and blackneſs. In the mean time, it may ſuffice, that you take notice with me, that the blind man's relations import no neceſſity of concluding, that though, becauſe, according to the judgment of his touch, black was the rougheſt, as it is the darkeſt of colours, therefore white, which (according to us) is the lighteſt, ſhould be alſo the ſmootheſt: ſince I obſerve, that he makes yellow to be two degrees more aſperous than blue, and as much leſs aſperous than green; whereas, indeed, yellow does not only appear to the eye a lighter colour than blue, but (by our firſt experiment hereafter to be mentioned) it will appear, that yellow reflected much more light than blue, and manifeſtly more than green; which we need not much wonder at, ſince in this colour, and the two others (blue and yellow) it is not only the reflected light that is to be conſidered, ſince to produce both theſe, refraction ſeems to intervene, which by its varieties may much alter the caſe: which both ſeems to ſtrengthen the conjecture I was formerly propoſing, that there was ſomething elſe in the kinds of aſperity, as well as in the degrees of it, which enabled our blind man to diſcriminate colours, and does at leaſt ſhow, that we cannot, in all caſes, from the bare difference in the degrees of aſperity betwixt colours, ſafely conclude, that the rougher of any two always reflects the leaſt light.

16. But this notwithſtanding, (*Pyrophilus*) and whatever curioſity I may have had to move ſome queſtions to our ſagacious blind man; yet thus much I think you will admit us to have gained by his teſtimony, that ſince many colours may be felt with the circumſtances above related, the ſurfaces of ſuch coloured bodies muſt certainly have differing degrees, and in all probability have differing forms or kinds of aſperity belonging to them, which is all the uſe that my preſent attempt obliges me to make of the hiſtory above delivered; that being ſufficient to prove, that colour does much depend upon the diſpoſition of the ſuperficial parts of bodies, and to ſhew in general, wherein it is probable that ſuch a diſpoſition does (principally at leaſt) conſiſt.

17. But to return to what I was ſaying, before I began to make mention of our blind organiſt; what we have delivered touching the cauſes of the ſeveral forms of aſperity that may diverſify the ſurfaces of coloured bodies, may perchance ſomewhat aſſiſt us to make ſome conjectures in the general, at ſeveral of the ways whereby it is poſſible for the experiments, hereafter to be mentioned, to produce the ſudden changes of colours that are wont to be conſequent upon them: for moſt of theſe phænomena being produced by the intervention of liquors, and theſe for the moſt part abounding with very minute, active, and variouſly figured ſaline corpuſcles, liquors ſo qualified may well enough very nimbly alter the texture of the body they are employed to work upon, and ſo may change the form of aſperity, and thereby make them remit to the eye the light that falls on them after another manner than they did before, and by that means vary the colour, ſo far forth as it depends upon the texture or diſpoſition of the ſeen parts of the object; which I ſay, *Pyrophilus*, that you may not think I would abſolutely exclude all other ways of modifying the beams of light between their parting from the lucid body, and their reception into the common ſenſory.

18. Now there ſeem to me divers ways, by which we may conceive that liquors may nimbly alter the colour of one another, and of other bodies, upon which they act; but my preſent haſte will allow me to mention but ſome of them, without inſiſting ſo much as upon thoſe I ſhall name.

19. And firſt, the minute corpuſcles that compoſe a liquor may eaſily inſinuate themſelves into thoſe pores of bodies, whereto their ſize and figure makes them congruous; and theſe pores they may either exactly fill, or but inadequately: and in this latter caſe they will for the moſt part alter the number and figure, and always the bigneſs of the former pores.

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And in what capacity ſoever theſe corpuſcles of a liquor come to be lodged or harboured in the pores that admit them, the ſurface of the body will for the moſt part have its aſperity altered, and the incident light that meets with a groſſer liquor in the little cavities that before contained nothing but air, or ſome yet ſubtiler fluid, will have its beams either refracted, or imbibed, or elſe reflected more or leſs interruptedly than they would be, if the body had been unmoiſtened: as we ſee, that even fair water falling on white paper, or linen, and divers other bodies apt to ſoak it in, will for ſome ſuch reaſons as thoſe newly mentioned, immediately alter the colour of them, and for the moſt part make it ſadder than that of the unwetted parts of the ſame bodies. And ſo you may ſee, that when in the ſummer the highways are dry and duſty, if there falls ſtore of rain, they will quickly appear of a much darker colour than they did before; and if a drop of oil be let fall upón a ſheet of white paper, that part of it, which by the imbibition of the liquor acquires a greater continuity, and ſome tranſparency, will appear much darker than the reſt, many of the incident beams of light being now tranſmitted, that otherwiſe would be reflected towards the beholder's eyes.

20. SECONDLY, A liquor may alter the colour of a body, by freeing it from thoſe things that hindered it from appearing in its genuine colour; and though this may be ſaid to be rather a reſtoration of a body to its own colour, or a retection of its native colour, than a change, yet ſtill there intervenes in it a change of the colour which the body appeared to be of before this operation. And ſuch a change a liquor may work, either by diſſolving, or corroding, or by ſome ſuch way of carrying off that matter, which either veiled or diſguiſed the colour that afterwards appears. Thus we reſtore old pieces of dirty gold to a clean and nitid yellow, by putting them into the fire, and into aqua-fortis, which take off the adventitious filth that made that pure metal look of a dirty colour: and there is alſo an eaſy way to reſtore ſilver coins to their due luſtre, by fetching off that which diſcoloured them. And I know a chymical liquor, which I employed to reſtore pieces of cloth ſpotted with greaſe to their proper colour, by imbibing the ſpotted part with this liquor, which incorporating with the greaſe, and yet being of a very volatile nature, does eaſily carry it away with it ſelf. And I have ſometimes tried, that by rubbing upon a good touch-ſtone a certain metalline mixture ſo compounded, that the impreſſion it left upon the ſtone appeared of a very differing colour from that of gold, yet a little of aqua-fortis would in a trice make the golden colour diſcloſe it ſelf, by diſſolving the other metalline corpuſcles that concealed thoſe of the gold, which you know that menſtruum will leave untouched.

21. THIRDLY, A liquor may alter the colour of a body by making a comminution of its parts, and that principally two ways; the firſt by disjoining and diſſipating thoſe cluſters of particles, if I may ſo call them, which ſtuck more looſely together, being faſtened only by ſome more eaſily diſſoluble cement, which ſeems to be the caſe of ſome of the following experiments, where you will find the colour of many corpuſcles brought to cohere by having been precipitated together, deſtroyed by the affuſion of very piercing and inciſive liquors. The other of the two ways I was ſpeaking of, is, by dividing the groſſer and more ſolid particles into minute ones, which will be always leſſer, and for the moſt part otherwiſe ſhaped than the entire corpuſcle ſo divided, as it will happen in a piece of wood reduced into ſplinters or chips, or as when a piece of cryſtal heated red-hot and quenched in cold water is cracked into a multitude of little fragments, which though they fall not aſunder, alter the diſpoſition of the body of the cryſtal, as to its manner of reflecting the light, as we ſhall have occaſion to ſhew hereafter.

22. THERE is a fourth way contrary to the third, whereby a liquor may change the colour of another body, eſpecially of another fluid; and that is, by procuring the coalition of ſeveral particles that before lay too ſcattered and diſperſed to exhibit the colour that afterwards appears. Thus ſometimes when I have had the ſolution of gold ſo dilated, that I doubted whether the liquor had really imbibed any true gold or no, by pouring in a little mercury, I have been quickly able to ſatisfy my ſelf, that the liquor contained gold; that metal after a little while cloathing the ſurface of the quickſilver with a thin film of its own livery. And chiefly, though not only by this way of bringing the minute parts of bodies together in ſuch numbers, as to make them become notorious to the eye, many of theſe colours ſeem to be generated which are produced by precipitations, eſpecially by ſuch as are wont to be made with fair water; as when reſinous gums diſſolved in ſpirit of wine, are let fall again, if the ſpirit be copiouſly diluted with that weakening liquor. And ſo out of the rectified and tranſparent butter of antimony, by the bare mixture of fair water, there will be plentifully precipitated that milk-white ſubſtance, which by having its looſer ſalts well waſhed off, is turned into that medicine, which vulgar chymiſts are pleaſed to call *Mercurius Vitæ*.

23. A FIFTH way, by which a liquor may change the colour of a body, is, by diſlocating the parts, and putting them out of their former order into another, and perhaps alſo altering the poſture of the ſingle corpuſcles as well as their order or ſituation in reſpect of one another. What certain kinds of commotion or diſlocation of the parts of a body may do towards the changing its colour, is not only evident in the mutations of colour obſervable in quickſilver, and ſome other concretes long kept by chymiſts in a convenient heat, though in cloſe veſſels, but in the obvious degenerations of colour, which every body may take notice of in bruiſed cherries, and other fruit, by comparing after a while the colour of the injured with

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with that of the ſound part of the ſame fruit. And that alſo ſuch liquors, as we have been ſpeaking of, may greatly diſcompoſe the textures of many bodies, and thereby alter the diſpoſition of their ſuperficial parts, the great commotion made in metals, and ſeveral other bodies by aqua-fortis, oil of vitriol, and other ſaline menſtruums, may eaſily perſuade us; and what ſuch varied ſituations of parts may do towards the diverſifying of the manner of their reflecting the light, may be gueſſed in ſome meaſure by the beating of tranſparent glaſs into a white powder, but far better by the experiments lately pointed at, and hereafter delivered, as the producing and deſtroying colours by the means of ſubtile ſaline liquors, by whoſe affuſion the parts of other liquors are manifeſtly both agitated, and likewiſe diſpoſed after another manner than they were before ſuch affuſion. And in ſome chymical oils, as particularly that of lemon peels, by barely ſhaking the glaſs that holds it into bubbles, that tranſpoſition of the parts which is conſequent to the ſhaking, will ſhew you on the ſurfaces of the bubbles exceeding orient and lively colours, which, when the bubbles relapſe into the reſt of the oil, do immediately vaniſh.

24. I KNOW not, *Pyrophilus*, whether I ſhould mention as a diſtinct way, becauſe it is of a ſomewhat more general nature, that power whereby a liquor may alter the colour of another body, by putting the parts of it into motion; for though poſſibly the motion ſo produced does, as ſuch, ſeldom ſuddenly change the colour of the body whoſe parts are agitated, yet this ſeems to be one of the moſt general, however not immediate cauſes of the quick change of colours in bodies. For the parts being put into motion by the adventitious liquor, divers of them that were before united, may become thereby disjoined, and when that motion ceaſes or decays, others of them may ſtick together, and that in a new order, by which means the motion may ſometimes produce permanent changes of colours, as in the experiment you will meet with hereafter, of preſently turning a ſnowy white body into a yellow, by the bare affuſion of fair water, which probably ſo diſſolves the ſaline corpuſcles that remained in the calx, and ſets them at liberty to act upon one another, and the metal, far more powerfully than the water without the aſſiſtance of ſuch ſaline corpuſcles could do. And though you rub blue vitriol, how venereal and unſophiſticated ſoever it be, upon the whetted blade of a knife, it will not impart to the iron its latent colour; but if you moiſten the vitriol with your ſpittle, or common water, the particles of the liquor disjoining thoſe of the vitriol, and thereby giving them the various agitation requiſite to fluid bodies, the metalline corpuſcles of the thus diſſolved vitriol will lodge themſelves in throngs in the ſmall and congruous pores of the iron they are rubbed on, and ſo give the ſurface of it the genuine colour of the copper.

25. There remains yet a way, *Pyrophilus*, to be mentioned, by which a liquor may alter the colour of another body, and this ſeems the moſt important of all, becauſe though it be named but as one, yet it may indeed comprehend many; and that is, by aſſociating the ſaline corpuſcles, or any other ſort of the more rigid ones of the liquor, with the particles of the body that it is employ'd to work upon. For theſe adventitious corpuſcles aſſociating themſelves with the protuberant particles of the ſurface of a coloured body, muſt neceſſarily alter their bigneſs, and will moſt commonly alter their ſhape. And how much the colours of bodies depend upon the bulk and figure of their ſuperficial particles, you may gueſs by this, that eminent ancient philoſophers, and divers moderns, have thought that all colours might, in a general way, be made out by theſe two; whoſe being diverſified will, in our caſe, be attended with theſe two circumſtances; the one, that the protuberant particles being increaſed in bulk, they will oftentimes be varied as to the cloſeneſs or laxity of their order, fewer of them being contained within the ſame ſenſible (though minute) ſpace than before; or elſe by approaching to one another, they muſt ſtraiten the pores, and it may be too they will, by their manner of aſſociating themſelves with the protuberant particles, intercept new pores. And this invites me to conſider farther, that the adventitious corpuſcles I have been ſpeaking of, may likewiſe produce a great change, as well in the little cavities or pores, as in the protuberances of a coloured body; for, beſides what we have juſt now taken notice of, they may, by lodging themſelves in thoſe little cavities, fill them up, and it may well happen, that they may not only fill the pores they inſinuate themſelves into, but likewiſe have their upper parts extant above them; and partly by theſe new protuberances, partly by increaſing the bulk of the former, theſe extraneous corpuſcles may much alter the number and bigneſs of the ſurface's pores, changing the old and intercepting new ones. And then 'tis odds, but the order of the little extancies, and conſequently that of the little depreſſions in point of ſituation will be altered likewiſe: as if you diſſolve quickſilver in ſome kind of aqua-fortis, the ſaline particles of the menſtruum, aſſociating themſelves with the mercurial corpuſcles, will make a green ſolution, which afterwards eaſily enough degenerates. And red lead, or minium, being diſſolved in ſpirit of vinegar, yields not a red, but a clear ſolution, the redneſs of the lead being by the liquor deſtroyed. But a better inſtance may be taken from copper; for I have tried, that if upon a copper-plate, you let ſome drops of weak aqua-fortis reſt for a while, the corpuſcles of the menſtruum joining with thoſe of the metal, will produce a very ſenſible aſperity upon the ſurface of the plate, and will concoagulate that way into very minute grains of a pale blue vitriol; whereas if upon another part of the ſame plate you ſuffer a little ſtrong ſpirit of urine to reſt a competent time, you ſhall find the aſperated ſurface adorned with a deeper and richer blue. And the ſame aqua-fortis, that will quickly change the redneſs of red

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lead into a darker colour, will, being put upon crude lead, produce a whitiſh ſubſtance, as with copper it did a blueiſh. And as with iron it will produce a reddiſh, and on white quills a yellowiſh, ſo much may the coalition of the parts of the ſame liquor, with the differingly figured particles of ſtable bodies, divers ways aſperate the differingly diſpoſed ſurfaces, and ſo diverſify the colour of thoſe bodies. And you will eaſily believe, that in many changes of colour, that happen upon the diſſolutions of metals, and precipitations made with oil of tartar, and the like fixed ſalts, there may intervene a coalition of ſaline corpuſcles with the particles of the body diſſolved or precipitated, if you examine how much the vitriol of a metal may be heavier than the metalline part of it alone, upon the ſcore of the ſaline parts concoagulated therewith; and, that in ſeveral precipitations the weight of the calx does for the ſame reaſon much exceed that of the metal, when it was firſt put in to be diſſolved.

26. BUT, *Pyrophilus*, to conſider theſe matters more particularly would be to forget that I declared againſt adventuring, at leaſt for this time, at particular theories of colours, and that accordingly you may juſtly expect from me rather experiments than ſpeculations: and therefore I ſhall diſmiſs this ſubject of the forms of ſuperficial aſperity in coloured bodies, as ſoon as I ſhall but have named to you, by way of ſupplement to what we have hitherto diſcourſed in this ſhort ſection, a couple of particulars, (which you will eaſily grant me;) the one, that there are divers other ways for the ſpeedy production even of true and permanent colours in bodies, beſides thoſe practicable by the help of liquors: for proof of which advertiſement, though ſeveral examples might be alledged, yet I ſhall need but re-mind you of what I mentioned to you above, touching the change of colours ſuddenly made on tempered ſteel, and on lead, by the operation of heat, without the intervention of a liquor. But the other particular I am to obſerve to you, is of more importance to our preſent ſubject; and it is, that though nature and art may in ſome caſes ſo change the aſperity of the ſuperficial parts of a body, as to change its colour by either of the ways I have propoſed, ſingle or un-aſſiſted; yet for the moſt part it is by two or three, or perhaps by more of the fore-mentioned ways aſſociated together, that the effect is produced. And if you conſider how variouſly theſe ſeveral ways and ſome others allied unto them, which I have left unmentioned, may be compounded and applied, you will not much wonder that ſuch fruitful, whether principles (or manners of diverſification) ſhould be fitted to change or generate no ſmall ſtore of differing colours.

27. HITHERTO, *Pyrophilus*, we have in diſcourſing of the aſperity of bodies conſidered the little protuberances of other ſuperficial particles which make up that roughneſs, as if we took it for granted, that they muſt be perfectly opacous and impenetrable by the beams of light, and ſo muſt contribute to the variety of colours, as they terminate more or leſs light, and reflect it to the eye mixed with more or leſs of thus or thus mingled ſhades. But to deal ingenuouſly with you, *Pyrophilus*, before I proceed any further, I muſt not conceal from you, that I have often thought it worth a ſerious inquiry, whether or no particles of matter, each of them ſingly inſenſible, and therefore ſmall enough to be capable of being ſuch minute particles, as the Atomiſts both of old and of late have (not abſurdly) called *Corpuſcula Coloris*, may not yet conſiſt each of them of divers yet minuter particles, betwixt which we may conceive little commiſſures where they adhere to one another, and, however, may not be porous enough to be, at leaſt in ſome degree, pervious to the unimaginably ſubtile corpuſcles that make up the beams of light, and conſequently to be in ſuch a degree diaphanous. For, *Pyrophilus*, that the propoſed inquiry may be of moment to him that ſearches after the nature of colour, you will eaſily grant, if you conſider, that whereas perfectly opacous bodies can but reflect the incident beams of light, thoſe that are diaphanous are qualified to refract them too; and that refraction has ſuch a ſtroke in the production of colours, as you cannot but have taken notice of, and perhaps admired in the colurs generated by the trajection of light through drops of water that exhibit a rainbow, through priſmatical glaſſes, and through divers other tranſparent bodies. But 'tis like, *Pyrophilus*, you will more eaſily allow that about this matter it is rather important to have a certainty, than that it is rational to entertain a doubt; wherefore I muſt mention to you ſome of the reaſons that make me think it may need a further inquiry: for I find that in a darkened room, where the light is permitted to enter but at one hole, the little wandering particles of duſt, that are commonly called motes, and, unleſs in the ſun-beams, are not taken notice of by the unaſſiſted ſight; I have, I ſay, often obſerved that theſe roving corpuſcles being looked on by an eye placed on the one ſide of the beams that entered the little hole, and by the darkneſs having its pupil much enlarged, I could diſcern that theſe motes, as ſoon as they came within the compaſs of the luminous, whether cylinder or inverted cone, if I may ſo call it, that was made up by the unclouded beams of the ſun, did in certain poſitions appear adorned with very vivid colours, like thoſe of the rainbow, or rather like thoſe of very minute, but ſparkling fragments of diamonds: and as ſoon as the continuance of their motion had brought them to an inconvenient poſition in reference to the light and the eye, they were only viſible without darting any lively colours as before. Which ſeems to argue, that theſe little motes, or minute fragments of ſeveral ſorts of bodies reputed opacous, and only crumbled as to their exterior and looſer parts into duſt, did not barely reflect the beams that fell upon them, but remit them to the eye refracted too. We may alſo obſerve, that ſeveral bodies, (as well ſome of a vegetable, as others of an animal nature) which are wont to paſs for opacous, appear in great part tranſpa-

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rent, when they are reduced into thin parts, and held againſt a powerful light. This I have not only taken notice of in pieces of ivory reduced into thick leaves, as alſo in divers conſiderable thick ſhells of fiſhes, and in ſhaving of wood; but I have alſo found that a piece of deal, far thicker than one would eaſily imagine, being purpoſely interpoſed betwixt my eye placed in a room, and the clear day-light, was not only ſomewhat tranſparent, but (perhaps by reaſon of its gummous nature) appeared quite through of a lovely red. And in the darkened room above mentioned, bodies held againſt the hole at which the light entered, appeared far leſs opacous than they would elſewhere have done; inſomuch that I could eaſily and plainly ſee, through the whole thickneſs of my hand, the motions of a body placed (at a very near diſtance indeed, but yet) beyond it. And even in minerals, the opacity is not always ſo great as many think, if the body be made thin: for white marble, though of a pretty thickneſs, being within a due diſtance placed betwixt the eye and a convenient light, will ſuffer the motions of one's finger to be well diſcerned through it, and ſo will pieces, thick enough, of many common flints. But above all, that inſtance is remarkable, that is afforded us by *Muſcovy* glaſs, (which ſome call *Selenites*, others *Lapis Specularis*;) for though plates of this mineral, though but of a moderate thickneſs, do often appear opacous, yet if one of theſe be dexterouſly ſplit into the thinneſt leaves it is made up of, it will yield ſuch a number of them, as ſcarce any thing but experience could have perſuaded me; and theſe leaves will afford the moſt tranſparent ſort of conſiſtent bodies, that, for aught I have obſerved, are yet unknown; and a ſingle leaf or plate will be ſo far from being opacous, that it will ſcarce be ſo much as viſible. And multitudes of bodies there are, whoſe fragments ſeem opacous to the naked eye, which yet, when I have included them in good microſcopes, appeared tranſparent; but, *Pyrophilus*, on the other ſide I am not yet ſure that there are no bodies, whoſe minute particles even in ſuch a microſcope as that of mine, which I was lately mentioning, will not appear diaphanous. For having conſidered mercury precipitated *per ſe*, the little granules that made up the powder, looked like little fragments of coral beheld by the naked eye at a diſtance, (for very near at hand coral will ſometimes, eſpecially if it be good, ſhew ſome tranſparency.) Filings likewiſe of ſteel and copper, though in an excellent microſcope, and a fair day, they ſhowed like pretty big fragments of thoſe metals, and had conſiderable brightneſs on ſome of their ſurfaces, yet I was not ſatisfied, that I perceived any reflection from the inner parts of any of the filings. Nay, having looked in my beſt microſcope upon the red calx of lead, (commonly called *Minium*) neither I, nor any I ſhewed it to, could diſcern it to be other than opacous, though the day were clear, and the object ſtrongly enlightened. And the deeply red colour of vitriol appeared in the ſame microſcope (notwithſtanding the great comminution effected by the fire) but like groſſy beaten brick. So that, *Pyrophilus*, I ſhall willingly reſign you the care of making ſome further inquiries into the ſubject we have now been conſidering; for I confeſs, as I told you before, that I think that the matter may need a further ſcrutiny, nor would I be forward to determine how far or in what caſes the tranſparency or ſemi-diaphaneity of the ſuperficial corpuſcles of bigger bodies may have an intereſt in the production of their colours; eſpecially becauſe that even in divers white bodies, as beaten glaſs, ſnow and froth, where it ſeems manifeſt that the ſuperficial parts are ſingly diaphanous, (being either water, or air, or glaſs) we ſee not that ſuch variety of colours are produced as uſually are by the refraction of light even in thoſe bodies, when by their bigneſs, ſhape, *&c.* they are conveniently qualified to exhibit ſuch various and lively colours as thoſe of the rainbow, and of priſmatical glaſſes.

28. By what has been hitherto diſcourſed, *Pyrophilus*, we may be aſſiſted to judge of that famous controverſy which was of old diſputed betwixt the Epicureans and other Atomiſts on one ſide, and moſt other philoſophers on the other ſide; the former denying bodies to be coloured in the dark, and the latter making colour to be an inherent quality, as well as figure, hardneſs, weight, or the like. For though this controverſy be revived, and hotly agitated among the moderns, yet I doubt whether it be not in great part a nominal diſpute; and therefore let us, according to the doctrine formerly delivered, diſtinguiſh the acceptations of the word colour, and ſay, that if it be taken in the ſtricter ſenſe, the Epicureans ſeem to be in the right; for if colour be indeed, though not according to them, but light modified, how can we conceive that it can ſubſiſt in the dark, that is, where it muſt be ſuppoſed there is no light: but, on the other ſide, if colour be conſidered as a certain conſtant diſpoſition of the ſuperficial parts of the object to trouble the light they reflect after ſuch and ſuch a determinate manner, this conſtant, and if I may ſo ſpeak, modifying diſpoſition perſevering in the object, whether it be ſhined upon or no, there ſeems no juſt reaſon to deny, but that in this ſenſe, bodies retain their colour as well in the night as day; or, to ſpeak a little otherwiſe, it may be ſaid, that bodies are potentially coloured in the dark, and actually in the light. But of this matter diſcourſing more fully elſewhere, as it is a difficulty that concerns qualities in general, I ſhall forbear to inſiſt on it here.

CHAP. IV.

1. OF greater moment in the inveſtigation of the nature of colours is the controverſy, whether thoſe of the rainbow, and thoſe that are often ſeen in clouds, before the riſing, or after the ſetting of the ſun; and in a word, whether thoſe other colours, that are wont to be called emphatical, ought or ought not to be

be accounted true colours. I need not tell you that the negative is the common opinion, eſpecially in the ſchools, as may appear by that vulgar diſtinction of colours, whereby theſe under conſideration are termed apparent, by way of oppoſition to thoſe that in the other member of the diſtinction are called true or genuine. This queſtion I ſay ſeems to me of importance, upon this account, that it being commonly granted, (or however, eaſy enough to be proved) that emphatical colours are light it ſelf modified by refractions chiefly, with a concurrence ſometimes of reflections, and perhaps ſome other accidents depending on theſe two; if theſe emphatical colours be reſolved to be genuine, it will ſeem conſequent, that colours, or at leaſt divers of them, are but diverſifyed light, and not ſuch real and inherent qualities as they are commonly thought to be.

2. NOW ſince we are wont to eſteem the echoes and other ſounds of bodies, to be true ſounds, all their odours to be true odours, and (to be ſhort) ſince we judge other ſenſible qualities to be true ones, becauſe they are the proper objects of ſome or other of our ſenſes; I ſee not why emphatical colours, being the proper and peculiar objects of the organ of ſight, and capable to affect it as truly and as powerfully as other colours, ſhould be reputed but imaginary ones.

AND if we have (which perchance you will allow) formerly evinced colour, (when the word is taken in its more proper ſenſe) to be but modified light, there will be ſmall reaſon to deny theſe to be true colours, which more manifeſtly than others diſcloſe themſelves to be produced by diverſifications of the light.

3. THERE is indeed taken notice of, a difference betwixt theſe apparent colours, and thoſe that are wont to be eſteemed genuine, as to the duration, which has induced ſome learned men to call the former rather evanid than fantaſtical. But as the ingenious *Gaſſendus* does ſomewhere judiciouſly obſerve, if this way of arguing were good, the greenneſs of a leaf ought to paſs for apparent, becauſe, ſoon fading into a yellow, it ſcarce laſts at all, in compariſon of the greenneſs of an emerald. I ſhall add, that if the ſun-beams be in a convenient manner trajected through a glaſs priſm, and thrown upon ſome well ſhaded object within a room, the rainbow thereby painted on the ſurface of the body that terminates the beams, may oftentimes laſt longer than ſome colours I have produced in certain bodies, which would juſtly, and without ſcruple be accounted genuine colours, and yet ſuddenly degenerate, and loſe their nature.

4. A GREATER diſparity betwixt emphatical colours, and others, may perhaps be taken from this, that genuine colours ſeem to be produced in opacous bodies by reflection, but apparent ones in diaphanous bodies, and principally by refraction; I ſay principally, rather than ſolely, becauſe in ſome caſes reflection alſo may concur: but ſtill this ſeems not to conclude theſe latter colours not to be true ones. Nor muſt what has been newly ſaid of the differences of true and apparent colours, be interpreted in too unlimited a ſenſe, and therefore it may perhaps ſomewhat aſſiſt you, both to reflect upon the two foregoing objections, and to judge of ſome other paſſages which you will meet with in this tract, if I take this occaſion to obſerve to you, that if water be agitated into froth, it exhibits, you know, a white colour, which ſoon after it loſes upon the reſolution of the bubbles into air and water. Now in this caſe either the whiteneſs of the froth is a true colour, or not; if it be, then true colours, ſuppoſing the water pure and free from mixtures of any thing tenacious, may be as ſhort-lived as thoſe of the rainbow; alſo the matter, wherein the whiteneſs did reſide, may in a few moments perfectly loſe all footſteps or remains of it. And beſides, even diaphanous bodies may be capable of exhibiting true colours by reflection; for that whiteneſs is ſo produced, we ſhall anon make it probable. But if on the other ſide it be ſaid, that the whiteneſs of froth is an emphatical colour, then it muſt no longer be ſaid, that fantaſtical colours require a certain poſition of the luminary and the eye, and muſt be varied or deſtroyed by the change thereof, ſince froth appears white, whether the ſun be riſing or ſetting, or in the meridian, or any where between it and the horizon, and from what (neighbouring) place ſoever the beholder's eye looks upon it. And ſince by making a liquor tenacious enough, yet without deſtroying its tranſparency, or ſtaining it with any colour, you may give the little films, whereof the bubbles conſiſt, ſuch a texture as may make the froth laſt very many hours, if not ſome days, or even weeks, it will render it ſomewhat improper to aſſign duration for the diſtinguiſhing character to diſcriminate genuine from fantaſtical colours. For ſuch froth may much outlaſt the undoubtedly true colours of ſome of nature's productions, as in that gaudy plant, not undeſervedly called the *Marvel of Peru*, the flowers do ſo often fade the ſame day they are blown; and I have often ſeen a Virginian flower, which uſually withers within the compaſs of a day; and I am credibly informed, that not far from hence, a curious herboriſt has a plant, whoſe flowers periſh in about an hour. But, if the whiteneſs of water turned into froth muſt therefore be reputed emphatical, becauſe it appears not that the nature of the body is alter'd, but only that the diſpoſition of its parts, in reference to the incident light, is chang'd, why may not the whiteneſs be accounted emphatical too; which I ſhall ſhew anon to be producible, barely by ſuch another change in black horn: and yet this ſo eaſily acquired whiteneſs ſeems to be as truly its colour as the blackneſs was before, and at leaſt is more permanent than the greenneſs of leaves, the redneſs of roſes, and in ſhort, than the genuine colours of the moſt part of nature's productions. It may indeed be further objected, that according as the ſun or other luminous body changes place, theſe emphatical colours alter or vaniſh. But not to repeat what I have juſt now ſaid, I ſhall add, that if a piece of cloth in a draper's ſhop (in ſuch the light

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light being ſeldom primary) be variouſly folded, it will appear of differing colours, as the parts happen to be more illuminated, or more ſhaded; and if you ſtretch it flat, it will commonly exhibit ſome one uniform colour: and yet theſe are not wont to be reputed emphatical, ſo that the difference ſeems to be chiefly this, that in the caſe of the rain-bow, and the like, the poſition of the luminary varies the colour, and in the cloth I have been mentioning, the poſition of the object does it. Nor am I forward to allow, that in all caſes, the apparition of emphatical colours requires a determinate poſition of the eye; for if men will have the whiteneſs of froth emphatical, you know what we have already inferred from thence. Beſides, the ſun-beams trajected through a triangular glaſs, after the manner lately mentioned, will, upon the body that terminates them, paint a rain-bow, that may be ſeen, whether the eye be placed on the right hand of it, or the left, or above, or beneath it, or before or behind it: and though there may appear ſome little variation in the colours of the rain-bow beheld from differing parts of the room, yet ſuch a diverſity may be alſo obſerved by an attentive eye in real colours, looked upon under the like circumſtances. Nor will it follow, that becauſe there remain no footſteps of the colour upon the object, when the priſm is removed, that therefore the colour was not real, ſince the light was truly modified by the refraction and reflection it ſuffered in its trajection through the priſm; and the object in our caſe ſerv'd for a ſpecular body, to reflect that colour to the eye. And that you may not be ſtartled, *Pyrophilus*, that I ſhould venture to ſay, that a rough and coloured object may ſerve for a ſpeculum to reflect the artificial rain-bow I have been mentioning, conſider what uſually happens in darkened rooms, where a wall, or other body conveniently ſituated within, may ſo reflect the colours of bodies without the room, that they may very clearly be diſcerned and diſtinguiſhed; and yet it is taken for granted, that the colours ſeen in a darkened room, though they leave no traces of themſelves upon the wall or body that receives them, are the true colours of the external objects, together with which the colours of the images are moved, or do reſt. And the error is not in the eye, whoſe office is only to perceive the appearances of things, and which does truly ſo; but in the judging or eſtimative faculty, which miſtakingly concludes that colour to belong to the wall, which does indeed belong to the object, becauſe the wall is that from whence the beams of light, that carry the viſible ſpecies, do come in ſtrait lines directly to the eye: as for the ſame reaſon we are wont, at a certain diſtance from concave ſpherical glaſſes, to perſuade ourſelves, that we ſee the image come forth to meet us, and hang in the air betwixt the glaſs and us, becauſe the reflected beams, that compoſe the image croſs in that place where the image ſeems to be, and thence, and not from the glaſs, do in direct lines take their courſe to the eye. And upon the like cauſe it is, that divers deceptions in ſounds and other ſenſible objects do depend, as we elſewhere declare.

5. I KNOW not whether I need add, that I have purpoſely tried, (as you will find ſome pages hence, and will perhaps think ſomewhat ſtrange) that colours, that are called emphatical, becauſe not inherent in the bodies in which they appear, may be compounded with one another, as thoſe that are confeſſedly genuine may. But when all this is ſaid, *Pyrophilus*, I muſt advertiſe you, that it is but problematically ſpoken; and that though I think the opinion I have endeavoured to fortify probable, yet a great part of our diſcourſe concerning colours may be true, whether that opinion be ſo or not.

CHAP. V.

1. THERE are, you know, *Pyrophilus*, beſides thoſe obſolete opinions about colours, which have been long ſince rejected, very various theories, that have each of them, even at this day, eminent men for their abetters: for the Peripatetick ſchools, though they diſpute amongſt themſelves divers particulars concerning colours, yet in this they ſeem unanimouſly enough to agree, that colours are inherent and real qualities, which the light doth but diſcloſe, and not concur to produce. Beſides, there are moderns, who with a ſlight variation adopt the opinion of *Plato*; and as he would have colour to be nothing but a kind of flame conſiſting of minute corpuſcles, as it were darted by the object againſt the eye, to whoſe pores their littleneſs and figure made them congruous; ſo theſe would have colour to be an internal light of the more lucid parts of the object, darkened, and conſequently altered by the various mixtures of the leſs luminous parts. There are alſo others, who, in imitation of ſome of the ancient Atomiſts, make colour not to be lucid ſteam, but yet a corporeal effluvium iſſuing out of the coloured body; but the knowingeſt of theſe have of late reformed their hypotheſis, by acknowledging and adding, that ſome external light is neceſſary to excite, and, as they ſpeak, ſollicit theſe corpuſcles of colour, as they call them, and bring them to the eye. Another and more principal opinion of the modern philoſophers, to which this laſt named may by a favourable explication be reconciled, is that, which derives colours from the mixture of light and darkneſs, or rather light and ſhadows. And as for the Chymiſts, it is known, that the generality of them aſcribe the origin of colours to the ſulphureous principle in bodies; though I find, as I elſewhere largely ſhew, that ſome of the chiefeſt of them derive colours rather from ſalt than ſulphur, and others from the third hypoſtatical principle, mercury. And as for the Carteſians, I need not tell you, that they, ſuppoſing the ſenſation of light to be produced by the impulſe made upon the organs of ſight, by certain extremely minute and ſolid globules, to which the pores of the air and other diaphanous bodies are pervious, endeavour to derive the varieties of colours from the various pro-

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portion of the direct progreſs or motion of theſe globules to their circumvolution or motion about their own centre, by which varying proportion they are by this hypotheſis ſuppoſed qualified to ſtrike the optick nerve after ſeveral diſtinct manners, ſo to produce the perception of differing colours.

2. BESIDES theſe ſix principal hypotheſes, *Pyrophilus*, there may be ſome others, which though leſs known, may perhaps as well as theſe deſerve to be taken into conſideration by you; but that I ſhould copiouſly debate any of them at preſent, I preſume you will not expect, if you conſider the ſcope of theſe papers, and the brevity I have deſigned in them; and therefore I ſhall at this time only take notice to you in the general of two or three things, that do more peculiarly concern the treatiſe you have now in your hands.

3. AND firſt, though the embracers of the ſeveral hypotheſes I have been naming to you, by undertaking each ſect of them to explicate colours indefinitely by the particular hypotheſes they maintain, ſeem to hold it forth as the only needful theory about that ſubject; yet for my part I doubt, whether any one of all theſe hypotheſes have a right to be admitted excluſively to all others: for I think it probable, that whiteneſs and blackneſs may be explicated by reflection alone without refraction, as you will find endeavoured in the diſcourſe you will meet with ere long, of the origin of whiteneſs and blackneſs; and on the other ſide, ſince I have not found, that by any mixture of white and true black, (for there is a blueiſh black, which many miſtake for a genuine) there can be a blue, a yellow, or a red, to name no other colours, produced; and ſince we do find, that theſe colours may be produced in the glaſs priſm and other tranſparent bodies, by the help of refractions, it ſeems, that refraction is to be taken in, into the explication of ſome colours, to whoſe generation they ſeem to concur, either by making a further or other commixture of ſhades with the refracted light, or by ſome other way not now to be diſcourſed. And as it ſeems not improbable, that in caſe the pores of the air, and other diaphanous bodies be every where almoſt filled with ſuch globuli, as the Carteſians ſuppoſe, the various kind of motion of theſe globuli may in many caſes have no ſmall ſtroke in varying our perception of colour; ſo without the ſuppoſition of theſe globuli, which it is not ſo eaſy to evince, I think we may probably enough conceive in general, that the eye may be variouſly affected, not only by the entire beams of light that fall upon it, as they are ſuch; but by the order, and by the degree of ſwiftneſs, and in a word, by the manner, according to which the particles that compoſe each particular beam arrive at the ſenſory; ſo that whatever be the figure of the little corpuſcles, of which the beams of light conſiſt, not only the celerity or ſlowneſs of their revolution or rotation, in reference to their progreſſive motion, by their more abſolute celerity, their direct or undulating motion, and other accidents, which may attend their appulſe to the eye, may fit them to make differing impreſſions on it.

4. SECONDLY, For theſe and the like conſiderations, *Pyrophilus*, I muſt deſire, that you would look upon this little treatiſe, not as a diſcourſe written principally to maintain any of the fore-mentioned theories, excluſively to all others, or ſubſtitute a new one of my own; but as the beginning of a hiſtory of colours, upon which, when you and your ingenious friends ſhall have enriched it, a ſolid theory may be ſafely built. But yet becauſe this hiſtory is not meant barely for a regiſter of the things recorded in it, but for an apparatus to a ſound and comprehenſive hypotheſis, I thought fit ſo to temper the whole diſcourſe, as to make it as conducible as conveniently I can to that end: and therefore I have not ſcrupled to let you ſee, that I was willing, as to ſave you the labour of cultivating ſome theories, that I thought would never enable you to reach the ends you aim at, ſo to contract your enquiries into a narrow compaſs. For both which purpoſes I thought it requiſite to do theſe two things; the one, to ſet down ſome experiments, which by the help of the reflections and inſinuations that attend them, may aſſiſt you to diſcover the infirmneſs and inſufficiency both of the common Peripatetick doctrine, and of the now more applauded theory of the chymiſts about colour; becauſe theſe two doctrines having poſſeſſed themſelves, the one of the moſt part of the ſchools, and the other of the eſteem of the generality of phyſicians and other learned men, whoſe profeſſions and ways of ſtudy do not exact, that they ſhould ſcrupulouſly examine the very firſt and ſimpleſt principles of nature: I feared it would be to little purpoſe, without doing ſomething to diſcover the inſufficiency of theſe hypotheſes, that I ſhould, (which was the other thing I thought requiſite for me to do) ſet down among my other experiments thoſe in the greateſt number, that may let you ſee, that, till I ſhall be better informed, I incline to take colour to be a modification of light; and would invite you chiefly to cultivate that hypotheſis, and improve it to the making out of the generation of particular colours, as I have endeavoured to apply it to the explication of whiteneſs and blackneſs.

5. THIRDLY, But *Pyrophilus*, though this be at preſent the hypotheſis I prefer, yet I propoſe it but in a general ſenſe, teaching only, that the beams of light, modified by the bodies whence they are ſent (reflected or refracted) to the eye, produce there that kind of ſenſation, men commonly call colour. But whether I think this modification of the light to be performed by mixing it with ſhades, or by varying the proportion of the progreſs and rotation of the Carteſian *Globuli Cœleſtes*, or by ſome other way, which I am not now to mention, I pretend not here to declare; much leſs do I pretend to determine, or ſcarce ſo much as to hope to know all that were requiſite to be known, to give you, or even my ſelf, a perfect account of the theory of viſion and colours. For in order to ſuch an undertaking, I would

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would firſt know what light is, and if it be a body (as a body or the motion of a body it ſeems to be) what kind of corpuſcles for ſize and ſhape it conſiſts of, with what ſwiftneſs they move forwards, and whirl about their own centres. Then I would know the nature of refraction, which I take to be one of the abſtruſeſt things (not to explicate plauſibly, but to explicate ſatisfactorily) that I have met with in phyſicks. I would further know, what kind and what degree of commixture of darkneſs or ſhades is made by refractions, or reflections, or both, in the ſuperficial particles of thoſe bodies, that being ſhined upon, conſtantly exhibit the one, for inſtance, a blue, the other a yellow, the third a red colour. I would further know, why this contemperation of light and ſhade, that is made, for example, by the ſkin of a ripe cherry, ſhould exhibit a red, and not a green, and the leaf of the ſame tree ſhould exhibit a green rather than a red. And indeed, laſtly, why ſince the light that is modified into theſe colours conſiſts but of corpuſcles moved againſt the retina or pith of the optick nerve, it ſhould there not barely give a ſtroke, but produce a colour; whereas a needle wounding likewiſe the eye would not produce colour, but pain. Theſe, and perhaps other things I ſhould think requiſite to be known, before I ſhould judge my ſelf to have fully comprehended the true and whole nature of colours: and therefore, though by making the experiments and reflections delivered in this paper, I have endeavoured ſomewhat to leſſen my ignorance in this matter, and think it far more deſirable to diſcover a little, than to diſcover nothing; yet I pretend but to make it probable by the experiments I mention, that ſome colours may be plauſibly enough explicated in the general by the doctrine here propoſed. For whenſoever I would deſcend to the minute and accurate explication of particulars, I find my ſelf very ſenſible of the great obſcurity of things, without excepting thoſe, which we never ſee but when they are enlightned, and confeſs with *Scaliger*, *Latet natura hæc*, (ſays he, ſpeaking of that of colour) *& ſicut aliarum rerum ſpecies in profundiſſima caligine inſcitiæ humanæ.* *Exercitat.* 325. *Parag.* 4.

The Experimental Hiſtory of COLOURS.

PART II.

Of the Nature of Whiteneſs and Blackneſs.

CHAP. I.

1. THOUGH after what I have acknowledged, *Pyrophilus*, of the abſtruſe nature of colours in particular, you will eaſily believe, that I pretend not to give you a ſatisfactory account of whiteneſs and blackneſs; yet not wholly to fruſtrate your expectation of my offering ſomething by way of ſpecimen towards the explication of ſome colours in particular, I ſhall make choice of theſe as the moſt ſimple ones, (and by reaſon of their mutual oppoſition the leaſt hardly explicable) about which to preſent you my thoughts, upon condition you will take them at moſt to be my conjectures, not my opinions.

2. WHEN I applied my ſelf to conſider, how the cauſe of whiteneſs might be explained by intelligible and mechanical principles, I remembred not to have met with any thing among the ancient Corpuſcularian philoſophers, touching the quality we call whiteneſs, ſave that *Democritus* is by *Ariſtotle* ſaid to have aſcribed the whiteneſs of bodies to their ſmoothneſs, and on the contrary their blackneſs to their aſperity. But though about the latter of thoſe qualities his opinion be allowable, as we ſhall ſee anon; yet that he needs a favourable interpretation in what is delivered concerning the firſt, (at leaſt if his doctrine be not miſrepreſented in this point, as it has been in many others,) we ſhall quickly have occaſion to manifeſt. But amongſt the moderns, the moſt learned *Gaſſendus* in his ingenious epiſtle publiſhed in the year 1642, *De apparente magnitudine ſolis humilis & ſublimis*, reviving the atomical philoſophy, has, though but incidentally, delivered ſomething towards the explication of whiteneſs upon mechanical principles. And becauſe no man, that I know of, has done ſo before him, I ſhall, to be ſure to do him right, give you his ſenſe in his own words: *Cogites velim* (ſays he) *lucem quidem in diaphano nullius coloris videri, ſed in opaco tamen terminante candicare, ac tantò magis, quantò denſior ſeu collectior fuerit. Deinde aquam non eſſe quidem coloris ex ſe candidi, & radium tamen ex eâ reflexum verſus oculum candicare. Rurſus cum plana aquæ ſuperficies non niſi ex una parte eam reflexionem faciat: ſi contigerit tamen illam in aliquot bullas intumeſcere, bullam unamquamque reflectionem facere, & candoris ſpeciem creare certa ſuperficiei parte. Ad hæc ſpumam ex aqua pura non alia ratione videri candeſcere & albeſcere, quam quod ſit congeries confertiſſima minutiſſimarum bullarum, quarum unaquæque ſuum radium reflectit, unde continens candor alborve apparet. Denique nivem nihil aliud videri quam ſpeciem puriſſimæ ſpumæ ex bullulis quam minutiſſimis & confertiſſimis cohærentis. Sed ridiculum me exhibeam, ſi tales meas nugas uberius proponem.* *Epiſt.* 2. pag. 45.

Album quippe & nigrum, hoc quidem aſperum eſſe dicit, hoc verò læve. De ſenſu 3. *& ſenſil.* 3.

3. BUT though in this paſſage, that very ingenious perſon has anticipated part of what I ſhould ſay; yet I preſume you will for all that expect, that I ſhould give you a fuller account

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count of that notion of whiteneſs, which I have the leaſt exceptions to, and of the particulars whence I deduce it; which to do, I muſt mention to you the following experiments and obſervations.

WHITENESS then conſidered as a quality in the object ſeems chiefly to depend upon this, that the ſuperficies of the body, that is called white, is aſperated by almoſt innumerable ſmall ſurfaces; which being of an almoſt ſpecular nature, are alſo ſo placed, that ſome looking this way, and ſome that way, they yet reflect the rays of light that fall on them, not towards one another, but outwards towards the ſpectator's eye. In this rude and general account of whiteneſs, it ſeems, that beſides thoſe qualities, which are common to bodies of other colours, as for inſtance the minuteneſs and number of the ſuperficial parts, the two chief things attributed to bodies as white are made to be, firſt, that little protuberances and ſuperficial parts be of ſomewhat a ſpecular nature, that they may, as little looking-glaſſes, each of them reflect the beams it receives, (or the little picture of the ſun made on it) without otherwiſe conſiderably altering them; whereas in moſt other colours, they are wont to be much changed, by being alſo refracted, or by being returned to the eye, mixt with ſhades or otherwiſe. And next, that its ſuperficial parts be ſo ſituated, that they retain not the incident rays of light by reflecting them inwards, but ſend them almoſt all back; ſo that the outermoſt corpuſcles of a white body, having their various little ſurfaces of a ſpecular nature, a man can from no place behold the body, but that there will be among thoſe innumerable *ſuperficieculæ*, that look ſome one way, and ſome another, enough of them obverted to his eye, to afford, like a broken looking-glaſs a confuſed idea, or repreſentation of light, and make ſuch an impreſſion on the organ, as that for which men are wont to call a body white. But this notion will perhaps be beſt explained by the ſame experiments and obſervations, on which it is built, and therefore I ſhall now advance to them.

4. AND in the firſt place I conſider, that the ſun, and other powerfully lucid bodies, are not only wont to offend, which we call to dazle our eyes; but that if any colour be to be aſcribed to them as they are lucid, it ſeems it ſhould be whiteneſs. For the ſun at noon-day, and in clear weather, and when his face is leſs troubled, and as it were ſtained by the ſteams of ſublunary bodies, and when his beams have much leſs of the atmoſphere to traject in their paſſage to our eyes, appears of a colour more approaching to white, than when nearer the horizon: the interpoſition of certain ſorts of fumes and vapours make him oftentimes appear either red, or at leaſt more yellow. And when the ſun ſhines upon that natural looking-glaſs, a ſmooth water, that part of it, which appears to this or that particular beholder the moſt ſhined on, does to his eye ſeem far whiter than the reſt. And here I ſhall add, that I have ſometimes had the opportunity to obſerve a thing, that may make to my preſent purpoſe; namely, that when the ſun was veiled over as it were, with a thin white cloud, and yet was too bright to be looked upon directly without dazling, by caſting my eyes upon a ſmooth water, as we ſometimes do to obſerve eclipſes without prejudice to our eyes, the ſun then not far from the meridian appeared to me not red, but ſo white, that it was not without ſome wonder, that I made the obſervation. Beſides, though we in *Engliſh* are wont to ſay, a thing is red-hot, as an expreſſion of its being ſuperlatively *ignitum*, (if I may ſo ſpeak for want of a proper *Engliſh* word) yet in the forges of ſmiths, and the furnaces of other artificers, by that which they call a white heat, they mean a further degree of ignition, than by that which both they and we call a red heat.

5. SECONDLY, I conſider, that common experience informs us, that as much light over-powers the eye, ſo when the ground is covered with ſnow, (a body extremely white) thoſe that have weak eyes are wont to complain of too much light: and even thoſe, that have not, are generally ſenſible of an extraordinary meaſure of light in the air; and if they are fain to look very long upon ſnow, find their ſight offended by it. On which occaſion we may call to mind what *Xenophon* relates, that his *Cyrus* marching his army for divers days through mountains covered with ſnow, the dazling ſplendor of its whiteneſs prejudiced the ſight of very many of his ſoldiers, and blinded ſome of them; and other ſtories of that nature may be met with in writers of good note. And the like has been affirmed to me by credible perſons of my own acquaintance, and eſpecially by one, who, though ſkilled in phyſick, and not ancient, confeſſed to me, when I purpoſely aſked him, that not only during his ſtay in *Muſcovy* he found his eyes much impaired, by being reduced frequently to travel in the ſnow; but that the weakneſs of his eyes did not leave him when he left that country, but has followed him into theſe parts, and yet continues to trouble him. And to this doth agree what I as well as others have obſerved, namely, that when I travelled by night, when the ground was all covered with ſnow, though the night otherwiſe would not have been lightſome, yet I could very well ſee to chuſe my way. But much more remarkable to my preſent purpoſe is that, which I have met with in *Olaus Magnus*, concerning the way of travelling in winter in the Northern regions, where the days of that ſeaſon are ſo very ſhort: for after other things not needful to be here tranſcribed; *Iter*, ſays he, *diurnum duo ſcilicet montana milliaria (quæ* 12 *Italica ſunt) conficiunt. Nocte verò ſub ſplendidiſſima luna, duplatum iter conſumunt aut triplatum. Neque id incommodè fit, cum nivium reverberatione lunaris ſplendor ſublimes & declives campos illuſtret, ac etiam montium præcipitia ac noxias feras à longè proſpiciant evitandas.* Which teſtimony I the leſs ſcruple to alledge, becauſe that it agrees very well with what has been affirmed to me by a phyſician of *Moſcow*, whom the notion I have been treating of concerning whiteneſs invited me to aſk, whether he could not ſee much farther, when he travelled by night in *Ruſſia*

Gent. Septent. Hiſtor. lib. 4. cap. 13.

Ruſſia than he could do in *England*, or elſewhere, when there was no ſnow upon the ground; for this ingenious perſon informed me, that he could ſee things at a far greater diſtance, and with more clearneſs, when he travelled by night on the *Ruſſian* ſnow, though without the aſſiſtance of moon-ſhine, than we in theſe parts would eaſily be perſuaded. Though it ſeems not unlikely to me, that the intenſeneſs of the cold may contribute ſomething to the conſiderableneſs of the effect, by much clearing the air of darkiſh ſteams, which in theſe more temperate climates are wont to thicken it in ſnowy weather: for having purpoſely enquired of this doctor, and conſulted that ingenious navigator captain *James*'s voyage hereafter to be further mentioned, I find both their relations agree in this, that in dark froſty nights they could diſcover more ſtars, and ſee the reſt clearer, than we in *England* are wont to do.

6. I KNOW indeed, that divers learned men think, that ſnow ſo ſtrongly affects our eyes, not by a borrowed, but a native light; but I venture to give it as a proof, that white bodies reflect more light than others, becauſe having once purpoſely placed a parcel of ſnow in a room carefully darkened, that no celeſtial light might come to fall upon it, neither I, nor an ingenious perſon (ſkilled in opticks) whom I deſired for a witneſs, could find, that it had any other light than what it received. And however, it is uſual among thoſe that travel in dark nights, that the guides wear ſomething of white to be diſcerned by, there being ſcarce any night ſo dark, but that in the free air there remains ſome light, though broken and debilitated perhaps by a thouſand reflections from the opacous corpuſcles that ſwim in the air, and ſend it to one another before it comes to arrive at the eye.

7. THIRDLY, And the better to ſhew that white bodies reflect ſtore of light, in compariſon of thoſe that are otherwiſe coloured, I did in the darkened room, formerly mentioned, hold not far from the hole, at which the light was admitted, a ſheet only of white paper, from whence caſting the ſun-beams upon a white wall, whereunto it was obverted, it manifeſtly appeared both to me, and to the perſon I took for a witneſs of the experiment, that it reflected a far greater light, than any of the other colours formerly mentioned; the light ſo thrown upon the wall notably enlightning it, and by it a good part of the room. And yet further to ſhew you, that white bodies reflect the beams from them, and not towards themſelves, let me add, that ordinary burning glaſſes, ſuch as are wont to be employed to light tobacco, will not in a great while burn, or ſo much as diſcolour a ſheet of white paper. Inſomuch that even when I was a boy, and loved to make trials with burning-glaſſes, I could not but wonder at this odd phænomenon, which ſet me very early upon gueſſing at the nature of whiteneſs; eſpecially becauſe I took notice, that the image of the ſun upon a white paper was not ſo well defined (the light ſeeming too diffuſed) as upon black, and becauſe I tried, that blacking over the paper with ink, not only the ink would be quickly dried up, but the paper, that I could not burn before, would be quickly ſet on fire. I have alſo tried, that by expoſing my hand with a thin black glove over it to the warm ſun, it was thereby very quickly and conſiderably more heated, than if I took off the glove, and held my hand naked, or put on it another glove of thin but white leather. And having thus ſhewn you, *Pyrophilus*, that white bodies reflect the moſt light of any, let us now proceed to conſider, what is further to be taken notice of in them, in order to our preſent enquiry.

8. AND fourthly, whereas among the diſpoſitions we attributed to white bodies, we alſo intimated this, that ſuch bodies are apt, like ſpeculums, though but imperfect ones, to reflect the light that falls on them untroubled or unſtained we ſhall, beſides other particulars to be met with in theſe papers, offer you this in favour of the conjecture; that in the darkened room ſeveral times mentioned in this treatiſe, we tried, that the ſun-beams being caſt from a coloured body upon a neighbouring white wall, the determinate colour of the body was from the wall reflected to the eye; whereas we could in divers caſes manifeſtly alter the colour arriving at the eye, by ſubſtituting at a convenient diſtance, a (conveniently) coloured (and gloſſy) body, inſtead of the white wall: as by throwing the beams from a yellow body upon a blue, there would be exhibited a kind of green, as in the experiments about colours is more fully declared.

9. I KNOW not whether I ſhould on this occaſion take notice, that when, as when looking upon the calm and ſmooth ſurface of a river betwixt my eye and the ſun, it appeared to be a natural ſpeculum, wherein that part, which reflected to my eye the entire and defined image of the ſun, and the beams leſs remote from thoſe which exhibited that image, appeared indeed of a great and whitiſh brightneſs, but the reſt comparatively dark enough; if afterwards the ſuperficies chanced to be a little, but not much troubled by a gentle breath of wind, and thereby reduced into a multitude of ſmall and ſmooth ſpeculums, the ſurface of the river would, ſuitably to the doctrine lately delivered, at a diſtance appear very much of kin to white, though it would loſe that brightneſs or whiteneſs upon the return of the ſurface to calmneſs and an uniform level. And I have ſometimes, for trial ſake, brought by a lenticular glaſs the image of a river, ſhined upon by the ſun, into an upper room darkened, and diſtant about a quarter of a mile from the river; by which means the numerous declining ſurfaces of the water appeared ſo contracted, that upon the body, that received the images, the whole river appeared a very white object at two or three paces diſtance. But if we drew near it, this whiteneſs appeared to proceed from an innumerable company of lucid reflections, from the ſeveral gently waved ſuperficies of the water, which looked near at hand like a multitude of very little, but

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ſhining ſcales of fiſh, of which many did every moment diſappear, and as many were by the ſun, wind and river generated anew. But though this obſervation ſeemed ſufficiently to diſcover, how the appearing whiteneſs in that caſe was produced, yet in ſome other caſes water may have the ſame, though not ſo vivid a colour upon other accounts; for oftentimes it happens, that the ſmooth ſurface of the water does appear bright or whitiſh, by reaſon of the reflection not immediately of the images of the ſun, but of the brightneſs of the ſky; and in ſuch caſes a convenient wind may where it paſſes along make the ſurface look black, by cauſing many ſuch furrows and cavities, as may make the inflected ſuperficies of the water reflect the brightneſs of the ſky rather inward than outward. And again, if the wind increaſe into a ſtorm, the water may appear white, eſpecially near the ſhore and the ſhip; namely becauſe the rude agitation breaks it into foam or froth. So much do whiteneſs and blackneſs depend upon the diſpoſition of the ſuperficial parts of a body, to reflect the beams of light inward or outward. But that as white bodies reflect the moſt light of any, ſo their ſuperficial particles are, in the ſenſe newly delivered, of a ſpecular nature; I ſhall now further endeavour to ſhew, both by the making of ſpecular bodies white, and the making of a white body ſpecular.

10. IN the fifth place then, I will inform you, that (not to repeat what *Gaſſendus* obſerves concerning water) I have for curioſity ſake diſtilled quickſilver in a cucurbit, fitted with a capacious glaſs-head, and obſerved, that when the operation was performed by the degrees of fire requiſite for my purpoſe, there would ſtick to the inſide of the alembick a multitude of little round drops of mercury: and as you know, that mercury is a ſpecular body, ſo each of theſe little drops was a ſmall round looking-glaſs; and a multitude of them lying thick and near one another, they did both in my judgment, and that of thoſe invited to ſee it, make the glaſs they were faſtened to, appear manifeſtly a white body. And yet, as I ſaid, this whiteneſs depended upon the minuteneſs and nearneſs of the little mercurial globuli, the convexity of whoſe ſurfaces fitted them to repreſent in a narrow compaſs a multitude of little lucid images to differingly ſituated beholders. And here let me obſerve a thing, that ſeems much to countenance the notion I have been recommending; namely, that whereas divers parts of the ſky, and eſpecially the milky way, do to the naked eye appear white, (as the name it ſelf imports) yet the galaxy looked upon through the teleſcope does not ſhew white, but appears to be made up of a vaſt multitude of little ſtars; ſo that a multitude of lucid bodies, if they be ſo ſmall, that they cannot ſingly or apart be diſcerned by the eye, and if they be ſufficiently thick ſet by one another, may by their confuſed beams appear to the eye one white body. And why is it not poſſible, that the like may be done, when a multitude of bright and little corpuſcles being crouded together, are made to ſend together vivid beams to the eye, though they ſhine but, as the planets, by a borrowed light?

11. BUT to return to our experiments. We may take notice, that the white of an egg, though in part tranſparent, yet by its power of reflecting ſome incident rays of light, is in ſome meaſure a natural ſpeculum, being long agitated with a whiſk or ſpoon, loſes its tranſparency, and becomes very white, by being turned into froth, that is, into an aggregate of numerous ſmall bubbles, whoſe convex ſuperficies fits them to reflect the light every way outwards. And it is worth noting, that when water, for inſtance, is agitated into froth, if the bubbles be great and few, the whiteneſs will be but faint, becauſe the number of ſpecula within a narrow compaſs is but ſmall, and they are not thick ſet enough to reflect ſo many little images or beams of the lucid body, as are requiſite to produce a vigorous ſenſation of whiteneſs. And partly, leſt it ſhould be ſaid, that the whiteneſs of ſuch globulous particles proceeds from the air included in the froth, (which to make good, it ſhould be proved that the air it ſelf is white;) and partly, to illuſtrate the better the notion we have propoſed of whiteneſs, I ſhall add, that I purpoſely made this experiment: I took a quantity of fair water, and put to it, in a clear glaſs phial, a convenient quantity of oil or ſpirit of turpentine, becauſe that liquor will not incorporate with water, and yet is almoſt as clear and colourleſs as it. Theſe being gently ſhaken together, the agitation breaks the oil (which, as I ſaid, is indiſpoſed to mix like wine or milk *per minima* with the water) into a multitude of little globes, which each of them reflecting outwards a lucid image, make the imperfect mixture of the two liquors appear whitiſh; but if by vehemently ſhaking the glaſs, for a competent time, you make a further comminution of the oil into far more numerous and ſmaller globuli, and thereby confound it alſo better with the water, the mixture will appear of a much greater whiteneſs, and almoſt like milk: whereas if the glaſs be a while let alone, the colour will by degrees impair, as the oily globes grow fewer and bigger, and at length will quite vaniſh, leaving both the liquors diſtinct and diaphanous as before. And ſuch a trial hath not ill ſucceeded, when inſtead of the colourleſs oil of turpentine, I took a yellow mixture made of a good proportion of crude turpentine diſſolved in that liquor; and (if I miſ-remember not) it alſo ſucceeded better than one would expect, when I employed an oil brought by filings of copper, infuſed in it, to a deep green. And this (by the way) may be the reaſon, why oftentimes when the oils of ſome ſpices and of aniſeeds, *&c.* are diſtilled in a limbeck with water, the water (as I have ſeveral times obſerved) comes over whitiſh, and will perhaps continue ſo for a good while; becauſe if the fire be made too ſtrong, the ſubtile chymical oil is thereby much agitated and broken, and blended with the water in ſuch numerous and minute globules, as cannot eaſily in a ſhort time emerge to the top of the water, and whilſt they remain in it, make

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make it, for the reaſon newly intimated, look whitiſh. And perhaps upon the ſame ground a cauſe may be rendred, why hot water is obſerved to be uſually more opacous and whitiſh, than the ſame water cold; the agitation turning the more ſpirituous or otherwiſe conveniently diſpoſed particles of the water into vapours, thereby producing in the body of the liquor a multitude of ſmall bubbles, which interrupt the free paſſage, that the beams of light would elſe have every way, and from the innermoſt parts of the water reflect many of them outwards. Theſe and the like examples, *Pyrophilus*, have induced me to ſuſpect, that the ſuperficial particles of white bodies may for the moſt part be as well convex as ſmooth: I content my ſelf to ſay, *ſuſpect*, and *for the moſt part*, becauſe it ſeems not eaſy to prove, that when diaphanous bodies, as we ſhall ſee by and by, are reduced into white powders, each corpuſcle muſt needs be of a convex ſuperficies, ſince perhaps it may ſuffice that ſpecular ſurfaces look ſeveral ways. For (as we have ſeen) when a diaphanous body comes to be reduced to very minute parts, it thereby acquires a multitude of little ſurfaces within a narrow compaſs. And though each of theſe ſhould not be of a figure convenient to reflect a round image of the ſun, yet even from ſuch an inconveniently figured body there may be reflected ſome (either ſtreight or crooked) phyſical line of light; which line I call phyſical, becauſe it has ſome breadth in it, and in which line in many caſes ſome refraction of the light falling upon the body it depends on may contribute to the brightneſs: As if a ſlender wire, or ſolid cylinder of glaſs, be expoſed to the light, you ſhall ſee in ſome part of it a vivid line of light; and if we were able to draw out and lay together a multitude of theſe little wires or thrids of glaſs, ſo ſlender, that the eye could not diſcern a diſtance betwixt the luminous lines, there is little doubt (as far as I can gueſs by a trial purpoſely made with very ſlender, but far leſs ſlender thrids of glaſs, whoſe aggregate was looked upon one way white) but the whole phyſical ſuperficies compoſed of them would to the eye appear white; and if ſo, it will not be always neceſſary that the figure of thoſe corpuſcles, that make a body appear white, ſhould be globulous. And as for ſnow it ſelf, though the learned *Gaſſendus* (as we have ſeen above) makes it to ſeem nothing elſe but a pure frozen froth, conſiſting of exceedingly minute and thick-ſet bubbles; yet I ſee no neceſſity of admitting that, ſince not only by the variouſly and curiouſly figured ſnow, that I have divers times had the opportunity with pleaſure to obſerve, but alſo by the common ſnow, it rather doth appear both to the naked eye, and in a microſcope, often, if not moſt commonly, to conſiſt principally of little ſlender icicles of ſeveral ſhapes, which afford ſuch numerous lines of light, as we have been newly ſpeaking of.

12. SIXTHLY, If you take a diaphanous body, as for inſtance a piece of glaſs, and reduce it to powder, the ſame body, which, when it was entire, freely tranſmitted the beams of light, acquiring by contuſion a multitude of minute ſurfaces, each of which is as it were a little, but imperfect ſpeculum, is qualified to reflect, in a confuſed manner, ſo many either beams, or little and ſingly unobſervable images of the lucid body, that from a diaphanous it degenerates into a white body. And I remember, I have for trial's ſake taken lumps of rock cryſtal, and heating them red-hot in a crucible, I found, according to my expectation, that being quenched in fair water, even thoſe, that remained in ſeemingly entire lumps, exchanged their tranſlucency for whiteneſs, the ignition and extinction having as it were cracked each lump into a multitude of minute bodies, and thereby given it a great multitude of new ſurfaces. And even with diaphanous bodies, that are coloured, there may be this way a greater degree of whiteneſs produced, than one would lightly think; as I remember, I have by contuſion obtained whitiſh pouders of granates, glaſs of antimony, and emeralds finely beaten; and you may more eaſily make the experiment, by taking good venereal vitriol of a deep blue, and comparing with ſome of the entire cryſtals purpoſely reſerved ſome of the ſubtile powder of the ſame ſalt, which will comparatively exhibit a very conſiderable degree of whitiſhneſs.

13. SEVENTHLY, And as by a change of poſition in the parts, a body that is not white may be made white; ſo by a ſlight change of the texture of its ſurface, a white body may be deprived of its whiteneſs. For if (as I have tried in gold-ſmiths ſhops) you take a piece of ſilver, that has been freſhly boiled, as the artificers call it, (which is done by firſt bruſhing, and then decocting it with ſalt and tartar, and perhaps ſome other ingredients) you ſhall find it to be of a lovely white. But if you take a piece of ſmooth ſteel, and therewith burniſh a part of it, which may be preſently done, you ſhall find, that part will loſe its whiteneſs, and turn a ſpeculum, looking almoſt every where dark, as other looking-glaſſes do; which may not a little confirm our doctrine. For by this we may gueſs, what it is chiefly, that made the body white before, by conſidering that all, that was done to deprive it of that whiteneſs, was only to depreſs the little protuberances, that were before on the ſurface of the ſilver, into one continued ſuperficies, and thereby effect this, that now the image of the lucid body, and conſequently a kind of whiteneſs ſhall appear to your eye; but in ſome place of the greater ſilver looking-glaſs (whence the beams reflected at an angle equal to that wherewith they fall on it, may reach your eye) whilſt the aſperity remained undeſtroyed, the light falling on innumerable little ſpecula obverted ſome one way, and ſome another, did from all ſenſibly diſtinguiſhable parts of the ſuperficies reflect confuſed beams or repreſentations of light to the beholder's eye, from whence ſoever he chance to look upon it. And among the experiments annexed to this diſcourſe, you will find one, wherein, by the change of texture in bodies, whiteneſs is in a trice both generated and deſtroyed.

CHAP.

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CHAP. II.

1. WHAT we have diſcourſed of whiteneſs, may ſomewhat aſſiſt us to form a notion of blackneſs, thoſe two qualities being contrary enough to illuſtrate each other. Yet among the ancient philoſophers I find leſs aſſiſtance to form a notion of blackneſs than of whiteneſs; only *Democritus* in the paſſage above recited out of *Ariſtotle* has given a general hint of the cauſe of this colour, by referring the blackneſs of bodies to their aſperity. But this I call but a general hint, becauſe thoſe bodies that are green, and purple, and blue, ſeem to be ſo, as well as black ones, upon the account of their ſuperficial aſperity. But among the moderns, the formerly mentioned *Gaſſendus*, perhaps invited by this hint of *Democritus*, has incidentally in another epiſtle given us, though a very ſhort, yet a ſomewhat clearer account of the nature of blackneſs in theſe words; *Exiſtimare par eſt corpora ſuâpte naturâ nigra conſtare ex particulis, quarum ſuperficieculæ ſcabræ ſint, nec facilè lucem extrorſum reflectant.* I wiſh this ingenious man had enlarged himſelf upon this ſubject; for indeed it ſeems, that as that, which makes a body white, is chiefly ſuch a diſpoſition of its parts, that it reflects (I mean without much interruption) more of the light that falls on it, than bodies of any other colour do; ſo that, which makes a body black, is principally a peculiar kind of texture, chiefly of its ſuperficial particles, whereby it does as it were dead the light that falls on it, ſo that very little is reflected outwards to the eye.

2. AND this texture may be explicated two, and perhaps more than two ſeveral ways; whereof the firſt is by ſuppoſing in the ſuperficies of the black body a particular kind of aſperity, whereby the ſuperficial particles reflect but few of the incident beams outwards, and the reſt inwards towards the body it ſelf. As if, for inſtance, we ſhould conceive the ſurface of a black body to be aſperated by an almoſt numberleſs throng of little cylinders, pyramids, cones, and other ſuch corpuſcles, which, by their being thick ſet and erected, reflect the beams of light from one to another inwards, and ſend them to and fro ſo often, that at length they are loſt, before they can come to rebound out again to the eye. And this is the firſt of the two mentioned ways of explicating blackneſs. The other way is by ſuppoſing the texture of black bodies to be ſuch, that either by their yielding to the beams of light, or upon ſome other account, they do as it were dead the beams of light, and keep them from being reflected in any plenty, or with any conſiderable vigour or motion, outwards. According to this notion it may be ſaid, that the corpuſcles, that make up the beams of light, whether they be ſolary effluviums, or minute particles of ſome ætherial ſubſtance, thruſting on one another from the lucid body, do, falling on black bodies, meet with ſuch a texture, that ſuch bodies receive into themſelves, and retain almoſt all the motion communicated to them by the corpuſcles that make up the beams of light, and conſequently reflect but few of them, or thoſe but languidly, towards the eye; it happening here almoſt in like manner as to a ball, which thrown againſt a ſtone or floor would rebound a great way upwards, but rebounds very little or not at all, when it is thrown againſt water, or mud, or a looſe net, becauſe the parts yield, and receive into themſelves the motion, on whoſe account the ball ſhould be reflected outwards. But this laſt way of explicating blackneſs I ſhall content my ſelf to have propoſed, without either adopting it, or abſolutely rejecting it. For the hardneſs of touch-ſtones, black marble, and other bodies, that being black are ſolid, ſeem to make it ſomewhat improbable, that ſuch bodies ſhould be of ſo yielding a texture, unleſs we ſhould ſay, that ſome bodies may be more diſpoſed to yield to the impulſes of the corpuſcles of light by reaſon of a peculiar texture, than other bodies, that in other trials appear to be ſofter than they. But though the former of theſe two explications of blackneſs be that, by which we ſhall endeavour to give an account of it; yet, as we ſaid, we ſhall not abſolutely reject this latter, partly becauſe they both agree in this, that black bodies reflect but little of the light that falls on them, and partly becauſe it is not impoſſible, that in ſome caſes both the diſpoſition of the ſuperficial particles, as to figure and poſition, and the yielding of the body, or ſome of its parts, may jointly, though not in an equal meaſure concur to the rendering of a body black. The conſiderations, that induced me to propoſe this notion of blackneſs, as I explained it, are principally theſe:

3. FIRST, That as I lately ſaid, whiteneſs and blackneſs being generally reputed to be contrary qualities, whiteneſs depending, as I ſaid, upon the diſpoſition of the parts of a body to reflect much light, it ſeems likely, that blackneſs may depend upon a contrary diſpoſition of the black bodies ſurface; but upon this I ſhall not inſiſt.

4. NEXT then we ſee, that if a body of one and the ſame colour be placed, part in the ſun-beams, and part in the ſhade, that part which is not ſhined on will appear more of kin to blackneſs than the other, from which more light rebounds to the eye; and dark colours ſeem the blacker, the leſs light they are looked upon in; and we think all things black in the dark, when they ſend no beams to make impreſſions on our organs of ſight: ſo that ſhadows and darkneſs are near of kin, and ſhadow, we know, is but a privation of light: and accordingly blackneſs ſeems to proceed from the paucity of beams reflected from the black body to the eye; I ſay, the paucity of beams, becauſe thoſe bodies, that we call black, as marble, jett, *&c.* are ſhort of being perfectly ſo, elſe we ſhould not ſee them at all. But though the beams, that fall on the ſides of thoſe erected particles, that we have been mentioning, do few of them return outwards, yet thoſe, that fall upon the points of thoſe cylinders, cones, or pyramids, may thence rebound to the eye, though they make there but a faint impreſſion, becauſe they arrive not there, but mingled with a great proportion of little ſhades.

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This may be confirmed by my having procured a large piece of black marble well poliſhed, and brought to the form of a large ſpherical and concave ſpeculum; for on the inſide this marble being well poliſhed, was a kind of dark looking-glaſs, wherein I could plainly ſee a little image of the ſun, when that ſhined upon it. But this image was very far from offending and dazling my eyes, as it would have done from another ſpeculum; nor, though the ſpeculum were large, could I in a long time, or in a hot ſun, ſet a piece of wood on fire, though a far leſs ſpeculum of the ſame form, and of a more reflecting matter, would have made it flame in a trice.

5. And on this occaſion we may as well in reference to ſomething formerly delivered concerning whiteneſs, as in reference to what has been newly ſaid, ſubjoin what we further obſerved touching the differing reflections of light from white and black marble; namely, that having taken a pretty large mortar of white marble, new, and poliſhed in the inſide, and expoſed it to the ſun, we found, that it reflected a great deal of glaring light, but ſo diſperſed, that we could not make the reflected beams concur in any ſuch conſpicuous focus, as that newly taken notice of in the black marble; though perhaps there may enough of them be made to meet near the bottom, to make ſome kind of focus, eſpecially ſince by holding in the night-time a candle at a convenient diſtance, we were able to procure a concourſe of ſome, though not many of the reflected beams, at about two inches diſtant from the bottom of the mortar: but we found the heat even of the ſun-beams ſo diſperſedly reflected to be very languid, even in compariſon of the black marble's focus. And the little picture of the ſun, that appeared upon the white marble as a ſpeculum, was but very faint and exceeding ill defined. Secondly, that taking two pieces of plain and poliſhed ſurfaces, and caſting on them ſucceſſively the beams of the ſame candle, in ſuch manner, as that the neighbouring ſuperficies being ſhaded by an opacous and perforated body, the incident beams were permitted to paſs but through a round hole of about half an inch diameter, the circle of light, that appeared on the white marble, was in compariſon very bright, but very ill defined; whereas that on the black marble was far leſs luminous, but much more preciſely defined.

6. Thirdly, when you look upon a piece of linen, that has ſmall holes in it, thoſe holes appear very black, and men are often deceived in taking holes for ſpots of ink; and painters, to repreſent holes, make uſe of black; the reaſon of which ſeems to be, that the beams, that fall on thoſe holes, fall into them ſo deep, that none of them is reflected back to the eye. And in narrow wells part of the mouth ſeems black, becauſe the incident beams are reflected downwards from one ſide to another, till they can no more rebound to the eye.

We may conſider too, that if differing parts of the ſame piece of black velvet be ſtroaked oppoſite ways, the piece of velvet will appear of two diſtinct kinds of blackneſs, the one far darker than the other; of which diſparity the reaſon ſeems to be, that in the leſs obſcure part of the velvet, the little ſilken piles, whereof it is made up, being inclined, there is a greater part of each of them obverted to the eye; whereas in the other part the piles of ſilk being more erected, there are far fewer beams reflected outwards from the lateral parts of each pile; ſo that moſt of thoſe, that rebound to the eye, come from the tops of the piles, which make but a ſmall part of the whole ſuperficies, that may be covered by the piece of velvet. Which explication I propoſe, not that I think the blackneſs of the velvet proceeds from the cauſe aſſigned, ſince each ſingle pile of ſilk is black by reaſon of its texture, in what poſition ſoever you look upon it; but that the greater blackneſs of one of theſe tufts ſeems to proceed from the greater paucity of beams reflected from it, and that from the fewneſs of thoſe parts of a ſurface, that reflect beams, and the multitude of thoſe ſhaded parts, that reflect none. And I remember, that I have oftentimes obſerved, that the poſition of particular bodies far greater than piles of ſilk in reference to the eye, may, notwithſtanding their having each of them a colour of its own, make one part of their aggregate appear far darker than the other; for I have near great towns often taken notice, that a cart-load of carrots packed up appeared of a much darker colour when looked upon, where the points of the carrots were obverted to the eye, than where the ſides of them were ſo.

7. Fourthly, In a darkened room, I purpoſely obſerved, that if the ſun-beams, which came in at the hole, were received upon white or any other colour, and directed to a convenient place of the room, they would manifeſtly, though not all equally, increaſe the light of that part; whereas if we ſubſtituted, either a piece of black cloth or black velvet, it would ſo dead the incident beams, that the place (newly mentioned) whereto I obverted the black body, would be leſs enlightened than it was before, when it received its light but from the weak and oblique reflections of the floor and walls of a pretty large room, through which the beams, that came in at the hole, were confuſedly and brokenly diſperſed.

8. Fifthly, And to ſhew, that the beams, that fall on black bodies, as they do not rebound outwards to the eye, ſo they are reflected towards the body it ſelf, as the nature of thoſe erected particles, to which we have imputed blackneſs, requires, we will add an experiment, that will alſo confirm our doctrine touching whiteneſs; namely, that we took a broad and large tile, and having whitened over one half of the ſuperficies of it, and blacked the other, we expoſed it to the ſummer's ſun; and having let it lie there a convenient time (for the difference is more apparent, if it have not lain there too long) we found, as we expected, that whilſt the whited part of the tile remained cool enough, the blacked part of the ſame tile was grown not only ſenſible, but very hot, (ſometimes to a ſtrong degree.)

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And to ſatisfy ſome of our friends the more, we have ſometimes left upon the ſurface of the tile, beſides the white and black parts thereof, a part, that retained the native red of the tile it ſelf; and expoſing them to the ſun, we obſerved this laſt mentioned to have contracted a heat in compariſon of the white, but a heat inferior to that of the black; of which the reaſon ſeems to be, that the ſuperficial particles of black bodies, being, as we ſaid, more erected, than thoſe of white or red ones, the corpuſcles of light falling on their ſides, being for the moſt part reflected inward from one particle to another, and thereby engaged as it were, and kept from rebounding upwards, they communicate their briſk motion, wherewith they were impelled againſt the black body, (upon whoſe account, had they fallen upon a white body, they would have been reflected outwards) to the ſmall parts of the black body, and thereby produce in thoſe ſmall parts ſuch an agitation, as (when we feel it) we are wont to call heat. I have been lately informed, that an obſervation near of kin to ours has been made by ſome learned men in *France* and *Italy*, by long expoſing to a very hot ſun two pieces of marble, the one white and the other black. But though the obſervation be worthy of them, and may confirm the ſame truth with our experiment, yet beſides that our trial needs not the ſummer, nor any great heat to ſucceed, it ſeems to have this advantage above the other, that whereas bodies more ſolid, and of a cloſer texture, though they uſe to be more ſlowly heated, are wont to receive a greater degree of heat from the ſun or fire, than (*cæteris paribus*) bodies of a ſlighter texture; I have found by the information of ſtone-cutters, and by other ways of enquiry, that black marble is much ſolider and harder than white; ſo that poſſibly the difference betwixt the degrees of heat, they receive from the ſun-beams, will by many be aſcribed to the difference of their texture, rather than to that of their colour; though I think our experiment will make it probable enough, that the greater part of that difference may well be aſcribed to that diſpoſition of parts, which makes the one reflect the ſun-beams inward, and the other outwards. And with this doctrine accords very well, that rooms hung with black are not only darker than elſe they would be, but are wont to be warmer too; inſomuch that I have known a great lady, whoſe conſtitution was ſomewhat tender, complain, that ſhe was wont to catch cold, when ſhe went out into the air, after having made any long viſits to perſons, whoſe rooms were hung with black. And this is not the only lady I have heard complain of the warmth of ſuch rooms; which though perhaps it may be partly imputed to the effluvia of thoſe materials, wherewith the hangings were dyed, yet probably the warmth of ſuch rooms depends chiefly upon the ſame cauſe, that the darkneſs does; as (not to repeat what I formerly noted touching my gloves) to ſatisfy ſome curious perſons of that ſex, I have convinced them, by trial, that of two pieces of ſilken ſtuff given to me by themſelves, and expoſed in their preſence to the ſame window, ſhined on by the ſun, the white was conſiderably heated, when the black was not ſo much as ſenſibly ſo.

9. SIXTHLY, I remember, that acquainting one day a Virtuoſo of unſuſpected credit, that had viſited hot countries, with part of what I have here delivered concerning blackneſs, he related to me, by way of confirmation of it, a very notable experiment, which he had both ſeen others make, and made himſelf in a warm climate; namely, that having carefully blacked over eggs, and expoſed them to the hot ſun, they were thereby in no very long time well roaſted; to which effect I conceive the heat of the climate muſt have concurred with the diſpoſition of the black ſurface to reflect the ſun-beams inward: for I remember, that having made that among other trials in *England*, though in ſummer-time, the eggs I expoſed acquired indeed a conſiderable degree of heat, but yet not ſo intenſe a one, as proved ſufficient to roaſt them.

10. SEVENTHLY, and laſtly, our conjectures at the nature of blackneſs may be ſomewhat confirmed by the (formerly mentioned) obſervation of the blind *Dutchman*, that diſcerns colours with his fingers; for he ſays, that he feels a greater roughneſs upon the ſurfaces of black bodies, than upon thoſe of red, or yellow, or green. And I remember, that the diligent *Bartholinus* ſays, that a blind Earl of *Mansfield* could diſtinguiſh white from black only by the touch; which would ſufficiently argue a great diſparity in the aſperities, or other ſuperficial textures of bodies. of thoſe two colours, if the learned relater had affirmed the matter upon his own knowledge. *Hiſt. Anatom. Cent. 3. Hiſt. 44.*

11. THESE, *Pyrophilus*, are the chief things, that occur to me at preſent, about the nature of whiteneſs and blackneſs; which if they have rendered it ſo much as probable, that in moſt, or at leaſt many caſes, the cauſes of theſe qualities may be ſuch as I have adventured to deliver, it is as much as I pretend to. For till I have opportunity to examine the matter by ſome further trials, I am not ſure, but that in ſome white and black bodies, there may concur to the colour ſome peculiar texture or diſpoſition of the body, whereby the motion of the ſmall corpuſcles, that make up the incident beams of light, may be differingly modified, before they reach the eye; eſpecially in this, that white bodies do not only copiouſly reflect on thoſe incident corpuſcles outwards, but reflect them briſkly, and do not otherwiſe alter them in the manner of their motion. Nor ſhall I now ſtay to inquire, whether ſome of thoſe other ways (as a diſpoſition to alter the velocity, the rotation, or the order and manner of appulſe to the eye of the reflected corpuſcles, that compoſed the incident beams of light) which we mentioned, when we conſidered the production ofcolours in general, may not in ſome caſes be applicable to thoſe of white and black bodies: for I am yet ſo much a ſeeker in this matter, and ſo little wedded to the opinions

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opinions I have propoſed, that what I am to add, ſhall be but the beginning of a collection of experiments and obſervations towards the hiſtory of whiteneſs and blackneſs, without at preſent interpoſing my explications of them; that ſo I may aſſiſt your enquiries, without much foreſtalling or byaſſing your judgment.

EXPERIMENT in CONSORT,

Touching WHITENESS *and* BLACKNESS.

EXPERIMENT I.

HAVING promiſed in the 27th page of the foregoing diſcourſe of whiteneſs and blackneſs, to ſhew, that thoſe two colours may, by a change of texture in bodies, each of them apart diaphanous and colourleſs, be at pleaſure and in a trice as well generated as deſtroyed, we ſhall begin with experiments, that may acquit us of that promiſe.

TAKE then what quantity you pleaſe of fair water, and having heated it, put into it as much good common ſublimate, as it is able to diſſolve, and (to be ſure of having it well glutted) continue putting in the ſublimate, till ſome of it lie untouched in the bottom of the liquor. Filter this ſolution through cap-paper, to have it clear and limpid, and into a ſpoonful or two thereof (put into a clean glaſs-veſſel) ſhake about four or five drops (according as you took more or leſs of this ſolution) of good limpid ſpirits of urine, and immediately the whole mixture will appear white like milk; to which mixture if you preſently add a convenient proportion of rectified aqua-fortis (for the number of drops is hard to determine, becauſe of the differing ſtrength of the liquor, but eaſily found by trial) the whiteneſs will preſently diſappear, and the whole mixture become tranſparent; which you may, if you pleaſe, again reduce to a good degree of whiteneſs (though inferior to the firſt) only by a more copious affuſion of freſh ſpirit of urine. *N. B.* Firſt, that is is not ſo neceſſary to employ either aqua-fortis or ſpirit of urine about this experiment, but that we have made it with other liquors inſtead of theſe; of which perhaps more elſewhere. Secondly, that this experiment, though not made with the ſame menſtruums, not producing the ſame colour, is yet much of kin to that other to be mentioned in this tract, among our other experiments of colours, about turning a ſolution of precipitate into an orange colour; and the chymical reaſon being much alike in both, the annexing it to one of them may ſuffice for both.

EXPERIMENT II.

MAKE a ſtrong infuſion of broken galls in fair water; and having filtered it into a clean phial, add more of the ſame liquor to it, till you have made it ſomewhat tranſparent, and ſufficiently diluted the colour, for the credit of the experiment, leſt otherwiſe the darkneſs of the liquor might make it be objected, that it was already almoſt ink. Into this infuſion ſhake a convenient quantity of a clear, but very ſtrong ſolution of vitriol; and you ſhall immediately ſee the mixture turn black almoſt like ink, and ſuch a way of producing blackneſs is vulgar enough; but if preſently after you do upon this mixture drop a ſmall quantity of good oil of vitriol, and, by ſhaking the phial, diſperſe it nimbly through the two other liquors, you ſhall (if you perform your part well, and have employed oil of vitriol clear and ſtrong enough) ſee the darkneſs of the liquor preſently begin to be diſcuſſed, and grow pretty clear and tranſparent, loſing its inky blackneſs, which you may again reſtore to it by the affuſion of a ſmall quantity of a very ſtrong ſolution of ſalt of tartar. And though neither of theſe atramentous liquors will ſeem other than very pale ink, if you write with a clean pen dipt in them; yet that is common to them with ſome ſorts of ink, that prove very good when dry; as I have alſo found, that when I made theſe carefully, what I wrote with either of them, eſpecially with the former, would, when thoroughly dry, grow black enough not to appear bad ink. This experiment of taking away, and reſtoring blackneſs from and to the liquors, we have likewiſe tried in common ink; but there it ſucceeds not ſo well, and but very ſlowly, by reaſon that the gum wont to be employed in the making it does by its tenacity oppoſe the operations of the above mentioned ſaline liquors. But to conſider gum no more, what ſome kind of precipitation may have to do in the producing and deſtroying of inks without it, I have elſewhere given you ſome occaſion and aſſiſtance to inquire: but I muſt not now ſtay to do ſo my ſelf, only I ſhall take notice to you, that though it be taken for granted, that bodies will not be precipitated by alcalizate ſalts, that have not firſt been diſſolved in ſome acid menſtruums; yet I have found upon trials, which my conjectures led me to make on purpoſe, that divers vegetables, barely infuſed, or, but ſlightly decocted in common water, would, upon the affuſion of a ſtrong and clear lixivium of pot-aſhes, and much more of ſome other precipitating liquors that I ſometimes employ, afford good ſtore of a curdled matter, ſuch as I have had in the precipitations of vegetable ſubſtances, by the intervention of acid things; and that this matter was eaſily ſeparable from the reſt of the liquor, being left behind it in the filtre. And in making the firſt ink mentioned in this experiment, I found, that I could by filtration ſeparate pretty ſtore of

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a black pulverable ſubſtance, that remained in the filtre; and when the ink was made clear again by the oil of vitriol, the affuſion of diſſolved *ſal tartari* ſeemed but to precipitate, and thereby to unite and render conſpicuous the particles of the black mixture, that had before been diſperſed into very minute and ſingly inviſible particles by the inciſive and reſolving power of the highly corroſive oil of vitriol.

AND to manifeſt, *Pyrophilus*, that galls are not ſo requiſite as many ſuppoſe to the making atramentous liquors, we have ſometimes the following experiment: we took dried roſe-leaves, and decocted them for a while in fair water; into two or three ſpoonfuls of this decoction we ſhook a few drops of a ſtrong and well filtrated ſolution of vitriol (which perhaps, had it been green, would have done as well) and immediately the mixture did turn back, and when into this mixture, preſently after it was made, we ſhook a juſt proportion of aqua-fortis, we turned it from a black ink to a deep red one, which by the affuſion of a little ſpirit of urine may be reduced immediately to an opacous and blackiſh colour. And in regard, *Pyrophilus*, that in the former experiments, both the infuſion of galls, and the decoction of roſes, and the ſolution of copperas, employed about them, are endowed each of them with its own colour, there may be a more noble experiment of the ſudden production of blackneſs made by the way mentioned in the ſecond ſection of the ſecond part of our eſſays; for though upon the confuſion of the liquors there mentioned, there do immediately emerge a very black mixture; yet both the infuſion of orpiment and the ſolution of minium were, before their being joined together, limpid and colourleſs.

EXPERIMENT III.

IF pieces of white hartſhorn be with a competent degree of fire diſtilled in a glaſs-retort, they will, after the avolation of the phlegm, ſpirit, volatile ſalt, and the looſer and the lighter parts of the oleaginous ſubſtance, remain behind of a coal-black colour. And even ivory it ſelf being ſkilfully burnt (how I am wont to do it, I have elſewhere ſet down) affords painters one of the beſt and deepeſt blacks they have. And yet in the inſtance of diſtilled hartſhorn, the operation being made in glaſs-veſſels carefully cloſed, it appears there is no extraneous black ſubſtance, that inſinuates it ſelf into white hartſhorn, and thereby makes it turn black; but that the whiteneſs is deſtroyed, and the blackneſs generated, only by a change of texture, made in the burnt body, by the receſs of ſome parts, and the tranſpoſition of others. And though I remember not, that in many diſtillations of hartſhorn I ever found the *Cap. mort.* to paſs from black to a true whiteneſs, whilſt it continued in cloſed veſſels; yet having taken out the coal-black fragments, and calcined them in open veſſels, I could in few hours quite deſtroy that blackneſs, and without ſenſibly changing their bulk or figure, reduce them to great whiteneſs. So much do theſe two colours depend upon the diſpoſition of the little parts, that the bodies, wherein they are to be met with, do conſiſt of. And we find, that if white-wine tartar, or even the white cryſtals of ſuch tartar be burnt without being truly calcined, the *Cap. mortuum* (as the chymiſts call the more fixt part) will be black. But if you further continue the calcination, till you have perfectly incinerated the tartar, and kept it long enough in a ſtrong fire, the remaining calx will be white. And ſo we ſee, that not only other vegetable ſubſtances, but even white woods, as the hazel, will yield a black charcoal, and afterwards whitiſh aſhes; and ſo animal ſubſtances naturally white, as bones and egg-ſhells, will grow black upon the being burnt, and white again, when they are perfectly calcined.

EXPERIMENT IV.

BUT yet I much queſtion, whether that rule delivered by divers, as well as philoſophers as chymiſts, *aduſta nigra, ſed peruſta alba*, will hold as univerſally as is preſumed, ſince I have ſeveral examples to alledge againſt it. For I have found, that by burning alabaſter, ſo as both to make it appear to boil almoſt like milk, and to reduce it to a very fine powder, it would not at all grow black, but retain its pure and native whiteneſs; and though by keeping it longer than is uſual in the fire, I produced but a faint yellow, even in that part of the powder, that lay neareſt the top of the crucible; yet having purpoſely inquired of an experienced ſtone-cutter, who is curious enough in trying concluſions in his own trade, he told me he had found, that if alabaſter or plaiſter of *Paris* be very long kept in a ſtrong fire, the whole heap of burnt powder would exchange its whiteneſs for a much deeper colour than the yellow I obſerved. Lead being calcined with a ſtrong fire turns (after having perhaps run through divers other colours) into minium, whoſe colour we know is a deep red; and if you urge this minium, as I have purpoſely done with a ſtrong fire, you may much eaſier find a glaſſy and brittle body darker than minium, than any white calx or glaſs. It is known among chymiſts, that the white calx of antimony, by the further and more vehement operation of the fire, may be melted into glaſs, which we have obtained of a red colour, which is far deeper than that of the calx of burnt antimony. And though common glaſs of antimony being uſually adulterated with borax, have its colour thereby diluted, oftentimes to a very pale yellow; yet not only ours made more ſincerely was, as we ſaid, of a colour leſs remote from black, than was the calx; but we obſerved, that by melting it once or twice more, and ſo expoſing it to the further operation of the fire, we had, as we expected, the colour heightened. To which we ſhall add but this one inſtance, (which is worth the taking notice of, in reference to colours,) that, if you take blue, but unſophiſticated, vitriol, and burn it very ſlowly, and with

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with a gentle degree of heat, you may obſerve, that when it is burnt but a little, and yet ſo far as that you may rub it to pouder betwixt your fingers, it will be of a white or whitiſh colour; but if you proſecute the calcination, this body, which by a light aduſtion was made white, will paſs through other colours, as gray, yellowiſh, and red; and if you further burn it with a long and vehement fire, by that time it comes to be *peruſtum*, it will be of a dark purple, nearer to black, not only than the firſt calx, but than the vitriol before it at all felt the fire. I might add, that *Crocus Martis* (*per ſe*, as they call it) made by the laſting violence of the reverberated flames is not ſo near a-kin to white, as the iron or ſteel that afforded it was before its calcinations; but that I ſuppoſe, theſe inſtances may ſuffice to ſatisfy you, that minerals are to be excepted out of the forementioned rule, which perhaps, though it ſeldom fail in ſubſtances belonging to the vegetable or animal kingdom, may yet be queſtioned even in ſome of theſe, if that be true, which the judicious traveller *Bellonius* affirms, that charcoals made out of the wood of oxycedar are white: and I could not find, that though in retorts hart's-horn and other white bodies will be denigrated by heat, yet camphire would not at all loſe its whiteneſs, though I have purpoſely kept it in ſuch a heat, as made it melt and boil.

EXPERIMENT V.

AND now I ſpeak of camphire, it puts me in mind of adding this experiment, that though, as I ſaid, in cloſed glaſſes I could not denigrate it by heat, but it would ſublime to the ſides and top of the glaſs, as it was before; yet not only it will, being ſet on fire in the free air, ſend forth a copious ſmoke, but having purpoſely upon ſome of it that was flaming, clapt a large glaſs, almoſt in the form of a hive, (but more ſlender only) with a hole at the top, (which I cauſed to be made to try experiments of fire and flame in) it continued ſo long burning, that it lined all the inſide of the glaſs with a ſoot as black as ink, and ſo copious, that, the cloſeneſs of the veſſel conſidered, almoſt all that part of the white camphire, that did take fire, ſeemed to have been changed into that deep black ſubſtance.

EXPERIMENT VI.

AND this alſo brings into my mind another experiment, that I made about the production of blackneſs, whereof, for reaſons too long to be here deduced, I expected and found a good ſucceſs; and it was this: I took rectified oil of vitriol (that I might have the liquor clean as well as ſtrong) and by degrees mixt with it a convenient proportion of the eſſential oil, as chymiſts call it, of wormwood, drawn over with ſtore of water in a limbeck; and warily diſtilling the mixture in a retort, there remained a ſcarce credible quantity of dry matter, black as a coal. And becauſe the oil of wormwood, though a chymical oil drawn by a Virtuoſo, ſeemed to have ſomewhat in it of the colour of the plant, I ſubſtituted in its room the pure and ſubtile eſſential oil of winter-ſavory, and mixing little by little this liquor with (if I miſ-remember not) an equal weight of the formerly mentioned rectified oil of vitriol, and diſtilling them as before in a retort, beſides what there paſſed over into the receiver, even theſe two clear liquors left me a conſiderable proportion, (though not ſo great as the two former) of a ſubſtance black as pitch, which I yet keep by me as a rarity.

EXPERIMENT VII.

A WAY of whiting wax cheaply and in great quantity may be a thing of good œconomical uſe; and we have elſewhere ſet down the practice of tradſemen that blanch it; but here treating of whiteneſs only, in order to the philoſophy of colours, I ſhall not examine, which of the ſlow ways may be beſt employed, to free wax from the yellow melleous parts, but ſhall rather ſet down a quick way of making it white, though but in very ſmall quantities. Take then a little yellow wax, ſcraped or thinly ſliced, and putting it into a bolt's-head or ſome other convenient glaſs, pour to it a pretty deal of ſpirit of wine, and placing the veſſel in warm ſand, increaſe the heat by degrees, till the ſpirit of wine begin to ſimmer or to boil a little; and continuing that degree of fire, if you have put liquor enough, you will quickly have the wax diſſolved: then taking it off the fire, you may either ſuffer it to cool as haſtily as with ſafety to the glaſs you can, or pour it, whilſt it is yet hot, into a filtre of paper; and either in the glaſs where it cools, or in the filtre, you will ſoon find the wax and menſtruum together reduced into a white ſubſtance, almoſt like butter, which by letting the ſpirit exhale will ſhrink into a much leſſer bulk, but ſtill retaining its whiteneſs. And that, which is pretty in the working of this magiſtery of wax, is, that the yellowneſs vaniſhes, neither appearing in the ſpirit of wine, that paſſes limpid through the filtre, nor in the butter of wax, if I may ſo call it, that, as I ſaid, is white.

EXPERIMENT VIII.

THERE is an experiment, *Pyrophilus*, which though I do not ſo exactly remember; and though it be ſomewhat nice to make, yet I am willing to acquaint you with, becauſe the thing produced, though it be but a curioſity, is wont not a little to pleaſe the beholders; and it is a way of turning, by the help of a dry ſubſtance, an almoſt golden-coloured concrete into a white one. The ſeveral trials are not at preſent ſo freſh in my memory to enable me to tell you certainly, whether an equal only or a double weight of common ſublimate muſt be taken in reference to the tin-glaſs; but, if I miſtake not, there was in the experiment, that ſucceeded beſt, two parts of the former taken to one of the latter. Theſe ingredients being finely poudered and exactly

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mixed, we ſublimed together by degrees of fire (the due gradation of which is in this experiment a thing of main importance;) there aſcended a matter of a very peculiar texture; for it was for the moſt part made up of very thin, ſmooth, ſoft and ſlippery plates, almoſt like the fineſt ſort of ſcales of fiſhes, but of ſo lovely a white inclining to pearl-colour, and of ſo curious a colour and ſhining a gloſs, that they appeared in ſome reſpect little inferior to orient pearls, and in other regards, they ſeemed to ſurpaſs them, and were applauded for a ſort of the prettieſt trifles, that we had ever prepared to amuſe the eye. I will not undertake, that though you will hardly miſs changing the colour of your ſhining tin-glaſs, yet you will the firſt or perhaps the ſecond time hit right upon the way of making the gliſtering ſublimate I have been mentioning.

EXPERIMENT IX.

WHEN we diſſolve in aqua fortis a mixture of gold and ſilver melted into one lump, it uſually happens, that the pouder of gold, that falls to the bottom, as not being diſſoluble by that menſtruum, will not have its own yellow, but appear of a black colour, though neither the gold, nor the ſilver, nor the aqua fortis did before manifeſt any blackneſs. And divers alchymiſts, when they make ſolutions of minerals they would examine, are very glad, if they ſee a black pouder precipitated to the bottom, taking it for a hopeful ſign, that thoſe particles are of a golden nature, which appear in a colour ſo ordinary to gold parted from other metals by aqua fortis, that it is a trouble to the refiner to reduce the precipitated calx to its native colour. For though (as we have tried) that may be quickly enough done by fire, which will make this gold look very gloriouſly (as indeed it is at leaſt one of the beſt ways, that is practiſed for the refining of gold,) yet it requires both watchfulneſs and ſkill, to give it ſuch a degree of fire, as will ſerve to reſtore it to its luſtre, without giving it ſuch a one, as may bring it to fuſion, to which the minuteneſs of the corpuſcles it conſiſts of makes the pouder very apt. And this brings into my mind, that having taken a flat and bright piece of gold, that was refined by a curious and ſkilful perſon on purpoſe to try to what height of purity gold could be brought by art, I found that this very piece, as glorious as it looked, being rubbed a little upon a piece of fine clean linnen, did ſully it with a kind of black: and the like I have obſerved in refined ſilver, which I therefore mention, becauſe I formerly ſuſpected, that the impurity of the metal might have been the only cauſe of what I have divers times obſerved in wearing ſilver-hilted ſwords, namely, that where they rubbed upon my clothes, if they were of a light-coloured cloth, the affriction would quickly black them; and congruouſly hereunto I have found pens blacked almoſt all over, when I had a while carried them about me in a ſilver ink-caſe. To which I ſhall only add, that whereas in theſe ſeveral inſtances of denigration, the metals are worn off, or otherwiſe reduced into very minute parts, that circumſtance may prove not unworthy your notice.

EXPERIMENT X.

THAT a ſolution of ſilver does dye hair of a black colour, is a known experiment, which ſome perſons, more curious than dextrous, have ſo unluckily made upon themſelves, as to make their friends very merry. And I remember, that the other day I made my ſelf ſome ſport by an improvement of this obſervation; for having diſſolved ſome pure ſilver in aqua fortis, and evaporated the *menſtruum ad ſiccitatem*, as they ſpeak, I cauſed a quantity of fair water to be poured upon the calx two or three ſeveral times, and to be at each evaporated, till the calx was very dry, and all the greeniſh blueneſs, that is wont to appear in common cryſtals of ſilver, was quite carried away. Then I made thoſe I meant to deceive, moiſten ſome part of their ſkin with their own ſpittle, and ſlightly rub the moiſtened parts with a little of this prepared ſilver; whereupon they admired to ſee, that a ſnow-white body laid upon the white ſkin ſhould preſently produce a deep blackneſs, as if the ſtanis had been made with ink; eſpecially conſidering, that this blackneſs could not, like that produced by ordinary ink, be readily waſhed off, but required many hours, and part of it ſome days to its obliteration. And with the ſame white calx and a little fair water we likewiſe ſtained the white hafts of knives, with a laſting black in thoſe parts, where the calx was plentifully enough laid on; for where it was laid on but very thinly, the ſtain was not quite of ſo deep a colour.

EXPERIMENT XI.

THE cauſe of the blackneſs of thoſe many nations, which by one common name we are wont to call Negroes, has been long ſince diſputed of by learned men, who poſſibly had not done amiſs, if they had alſo taken into conſideration, why ſome whole races of other animals beſides men, as foxes and hares, are diſtinguiſhed by a blackneſs not familiar to the generality of animals of the ſame ſpecies. The general opinion (to be mentioned a little lower) has been rejected even by ſome of the ancient geographers, and among the moderns *Ortelius* and divers other learned men have queſtioned it. But this is no place to mention what thoughts I have had to and fro about theſe matters: only as I ſhall freely acknowledge, that to me the inquiry ſeems more abſtruſe than it does to many others, and that becauſe conſulting with authors, and with books of voyages, and with travellers, to ſatisfy my ſelf in matters of fact, I have met with ſome things among them, which ſeem not to agree very well with the notions of the moſt claſſick authors concerning theſe things; for it being my preſent work to deliver rather matters hiſtorical than theories, I ſhall annex ſome few of

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of my collections, inſtead of a ſolemn diſputation. It is commonly preſumed, that the heat of the climates, wherein they live, is the reaſon, why ſo many inhabitants of the ſcorching regions of *Africa* are black; and there is this familiar obſervation to countenance this conjecture, that we plainly ſee that mowers, reapers, and other country-people, who ſpend the moſt part of the hot ſummer days expoſed to the ſun, have the ſkin of their hands and faces, which are the parts immediately expoſed to the ſun and air, made of a darker colour than before, and conſequently, tending to blackneſs: and contrariwiſe we obſerve, that the Danes and ſome other people that inhabit cold climates, and even the Engliſh who feel not ſo rigorous a cold, have uſually whiter faces than the Spaniards, Portugals and other European inhabitants of hotter climates. But this argument I take to be far more ſpecious than convincing; for though the heat of the ſun may darken the colour of the ſkin by that operation, which we in Engliſh call ſun-burning; yet experience doth not evince, that I remember, that that heat alone can produce a diſcolouring, that ſhall amount to a true blackneſs, like that of Negroes; and we ſhall ſee by and by, that even the children of the Negroes not yet ten days old (perhaps not ſo much by three quarters of that time) will notwithſtanding their infancy be of the ſame hue with their parents. Beſides, there is a ſtrong argument to be alledged againſt the vulgar opinion, that in divers places in *Aſia* under the ſame parallel, or even of the ſame degree of latitude with the African regions inhabited by the Blacks, the people are at moſt but tawny; and in *Africa* it ſelf divers nations in the empire of *Ethiopia* are not Negroes, though ſituated in the torrid zone, and as near the equinoctial, as other nations that are ſo, (as the black inhabitants of *Zeylan* and *Malabar* are not in our globes placed ſo near the line as *Amara* the famouſeſt place in *Ethiopia*.) Moreover, (that which is of no ſmall moment in our preſent diſquiſition) I find not by the beſt navigators and travellers to the *Weſt-Indies*, whoſe books or themſelves I have conſulted on this ſubject, that excepting perhaps one place or two of ſmall extent, there are any Blacks originally natives of any part of *America* (for the Blacks now there have been long by the Europeans long tranſplanted thither) though the new world contain in it ſo great a variety of climates, and particularly reach quite croſs the torrid zone from one tropick to another. And though it be true, that the Danes be a whiter people than the Spaniards, yet that may proceed rather from other cauſes (not here to be enquired into) than from the coldneſs of the climate, ſince not only the Swedes and other inhabitants of thoſe cold countries, are not uſually ſo white as the Danes, nor whiter than other nations in proportion to their vicinity to the pole. [And ſince the writing of the former part of this eſſay, having an opportunity on a ſolemn occaſion to take notice of the numerous train of ſome extraordinary ambaſſadors ſent from the Ruſſian emperor to a great monarch, I obſerved, that (though it were then winter) the colour of their hair and ſkin was far leſs whitiſh than the Danes who inhabit a milder region is wont to be, but rather from the moſt part of a darkiſh brown; and the phyſician to the embaſſador, with whom thoſe Ruſſes came, being aſked by me, whether in *Muſcovy* it ſelf the generality of the people were more inclined to have dark-coloured hair than flaxen, he anſwered affirmatively; but ſeemed to ſuſpect, that the true and ancient Ruſſians, a ſept of whom he told me he had met with in one of the provinces of that vaſt empire, were rather white like the Danes than any thing near ſo brown as the preſent Muſcovites, whom he gueſſes to be deſcended of the Tartars, and to have inherited their colour from them.] But to proſecute our former diſcourſe, I ſhall add for further proof the conjecture I was countenancing, that good authors inform us, that there are Negroes in *Africa* not far from the *Cape of Good Hope*, and conſequently beyond the ſouthern tropick, and without the torrid zone, much about the ſame northern latitude (or very little more) wherein there are divers American nations, that are not Negroes, and wherein the inhabitants of *Candia*, ſome parts of *Sicily*, and even of *Spain*, are not ſo much as Tawny-moors. But (which is a freſh and ſtrong argument againſt the common opinion) I find by our recent relations of *Greenland*, (our accounts whereof we owe to the curioſity of that royal Virtuoſo the preſent King of *Denmark*,) that the inhabitants are olive-coloured, or rather of a darker hue. But if the caſe were the ſame with men, and thoſe other kinds of animals I formerly named, I ſhould offer ſomething as a conſiderable proof, that cold may do much towards the making men white or black; and however I ſhall ſet down the obſervation as I have met with it, as worthy to come into the hiſtory of whiteneſs and blackneſs; and it is, that in ſome parts of *Ruſſia* and of *Livonia* it is affirmed by *Olaus Magnus* and others, that hares and foxes (ſome add partridges) which before were black, or red, or grey, do in the depth of winter become white by reaſon of the great cold; (for that it ſhould be, as ſome conceive, by looking upon the ſnow, ſeems improbable upon divers accounts:) And I remember, that having purpoſely inquired of a Virtuoſo, who lately travelled through *Livonia* to *Moſco*, concerning the truth of this tradition, he both told me, he believed it, and added, that he ſaw divers of thoſe lately named animals either in *Ruſſia* or *Livonia*, (for I do not very well remember whether of the two) which, though white when he ſaw them in winter, they aſſured him had been black, or other colours, before the winter began, and would be ſo again when it was over. But for further ſatisfaction, I alſo conſulted one, that had for ſome years been an eminent phyſician in *Ruſſia*, who though he rejected ſome other traditions, that are generally enough believed concerning that country, told me nevertheleſs, that he ſaw no cauſe to doubt of this tradition of *Olaus Magnus*, as to foxes and hares; not only becauſe it is common

Olearius Voyage de Moſco & de Perſe. liv. 3.

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mon and uncontrouled aſſertion of the natives; but alſo becauſe he himſelf in the winter could never, that he remembred, ſee foxes and hares of any other colour than white. And I my ſelf having ſeen a ſmall white fox, brought out of *Ruſſia* into *England*, towards the latter end of winter, foretold thoſe, that ſhewed him me, that he would change colour in ſummer; and accordingly coming to look upon him again in *July*, I found, that the back and ſides, together with the upper part of the head and tail, were already grown of a dark colour, the lower part of the head and belly containing as yet a whiteneſs. Let me add, that were it not for ſome ſcruple I have, I ſhould think more than what *Olaus* relates confirmed by the judicious *Olearius*, who was twice employed into thoſe parts as a publick miniſter, who in his account of *Muſcovy* has this paſſage: *The hares there are grey; but in ſome provinces they grow white in the winter.* And within ſome few lines after; *It is not very difficult to find the cauſe of this change, which certainly proceeds only from the outward cold, ſince I know, that even in ſummer hares will change colour, if they be kept a competent time in a cellar.* I ſay, were it not for ſome ſcruple, becauſe I take notice, that in the ſame page the author affirms, that the like change of colour, that happens to hares in ſome provinces of *Muſcovy*, happens to them alſo in *Livonia*; and yet immediately ſubjoins, that in *Courland* the hares vary not their colour in winter; though theſe two laſt named countries be contiguous, that is, ſever'd only by the river of *Dugna*. For it is ſcarce conceivable how cold alone ſhould have, in countries ſo near, ſo ſtrangely differing an operation, though no leſs ſtrange a thing is confeſſed by many, that aſcribe the complexion of Negroes to the heat of the ſun, when they would have the river of *Cenega* ſo to bound the *Moors*, that though on the north-ſide they are but tawny, on the other ſide they are black.

THERE is another opinion concerning the complexion of Negroes, that is not only embraced by many of the more vulgar writers, but likewiſe by that ingenious traveller Mr. *Sandys*, and by a late moſt learned critick, beſides other men of note; and theſe would have the blackneſs of Negroes an effect of *Noah*'s curſe ratified by God's, upon *Cham*. But though I think, that even a Naturaliſt may without diſparagement believe all the miracles atteſted by the holy ſcriptures, yet in this caſe, to fly to a ſupernatural cauſe, will, I fear, look like ſhifting off the difficulty, inſtead of reſolving it; for we inquire not the firſt and univerſal, but the proper, immediate, and phyſical cauſe of the jetty colour of Negroes; and not only we do not find expreſſed in the ſcripture, that the curſe meant by *Noah* to *Cham* was the blackneſs of his poſterity, but we do find plainly enough there, that the curſe was quite another thing, namely, that he ſhould be a ſervant of ſervants, that is, by an Hebraiſm, a very abject ſervant to his brethren: which accordingly did in part come to paſs, when the Iſraelites of the poſterity of *Sem* ſubdued the Canaanites, that deſcended from *Cham*, and kept them in great ſubjection. Nor is it evident, that blackneſs is a curſe; for navigators tell us of black nations, who think ſo much otherwiſe of their own condition, that they paint the devil white. Nor is blackneſs inconſiſtent with beauty, which even to our European eyes conſiſts not ſo much in colour, as an advantageous ſtature, a comely ſymmetry of the parts of the body, and good features in the face. So that I ſee not, why blackneſs ſhould be thought ſuch a curſe to the Negroes, unleſs perhaps it be, that being wont to go naked in thoſe hot climates, the colour of their ſkin does probably, according to the doctrine above delivered, make the ſun-beams more ſcorching to them, than they would prove to a people of a white complexion.

GREATER probability there is, that the principal cauſe (for I would not exclude all concurrent ones) of the blackneſs of Negroes is ſome peculiar and ſeminal impreſſion: for not only we ſee, that Blackmoor boys, brought over into theſe colder climates, loſe not their colour; but good authors inform us, that the offſpring of Negroes tranſplanted out of *Africa*, above a hundred years ago, retain ſtill the complexion of their progenitors, though poſſibly in tract of time it will decay; as, on the other ſide, the white people removing into very hot climates, have their ſkins by the heat of the ſun ſcorched into dark colours; yet neither they, nor their children have been obſerved, even in the countries of Negroes, to deſcend to a colour amounting to that of the natives. Whereas I remember I have read in *Piſo*'s excellent account of *Braſil*, that betwixt the Americans and Negroes are generated a diſtinct ſort of men, which they call *Cabocles*; and betwixt Portugals and Æthiopian women, he tells us, he has ſometimes ſeen twins, whereof one had a white ſkin, the other a black: not to mention here ſome other inſtances he gives, that the productions of the mixtures of differing people, that is (indeed) the effects of ſeminal impreſſions, which they conſequently argue to have been their cauſes. And we ſhall not much ſcruple at this, if we conſider, that even organical parts may receive great differences from ſuch peculiar impreſſions, upon what account ſoever they came to be ſettled in the firſt individual perſons, from whom they are propagated to poſterity, as we ſee in the blobber-lips and flat-noſes of moſt nations of Negroes. And if we may credit what learned men deliver concerning the little feet of the Chineſes, the *Macrocephali* taken notice of by *Hippocrates* will not be the only inſtance we might apply to our preſent purpoſe. And on this occaſion it will not perchance be impertinent to add ſomething of what I have obſerved in other animals, as there are a ſort of hens, that want rumps; and that (not to mention, that in ſeveral places there is a ſort of crows or daws, that are not coal-black as ours, but partly of a whitiſh colour) in ſpight of *Porphyry*'s examples of inſeparable accidents, I have ſeen a perfectly white raven, as to bill as well as feathers, which I attentively conſidered, for fear of being impoſed upon. And this recalls into my memory, what

Piſo *Nat. & Med. Hiſt.* Braſil. lib. 1. *in fine.*

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what a very ingenious phyſician has divers times related to me of a young lady, to whom being called, he found, that though ſhe much complained of want of health, yet there appeared ſo little cauſe either in her body, or her condition, to gueſs, that ſhe did any more than fancy herſelf ſick, that ſcrupling to give her phyſick, he perſuaded her friends rather to divert her mind by little journeys of pleaſure; in one of which going to viſit St. *Winifred*'s well, this lady, who was a catholick, and devout in her religion, and a pretty while in the water to perform ſome devotions, and had occaſion to fix her eyes very attentively upon the red pebble-ſtones, which in a ſcattered order made up a good part of thoſe that appeared through the water, and a while after growing big, ſhe was delivered of a child, whoſe white ſkin was copiouſly ſpeckled with ſpots of the colour and bigneſs of thoſe ſtones; and though now this child have already lived ſeveral years, yet ſhe ſtill retains them. I have but two things to add concerning the blackneſs of Negroes; the one is, that the ſeat of that colour ſeems to be but the thin epidermis, or outward ſkin; for I knew a young Negro, who having been lightly ſick of the ſmall-pox or meaſles, (for it was doubted, which of the two was his diſeaſe) I found by inquiry of a perſon, that was concerned for him, that in thoſe places the little tumours had broke their paſſage through the ſkin, when they were gone, they left whitiſh ſpecks behind them; and the lately commended *Piſo* aſſures us, that having the opportunity in *Braſil* to diſſect many Negroes, he clearly found, that their blackneſs went no deeper than the very outward ſkin, which cuticula or epidermis being removed, the undermoſt ſkin or cutis appeared juſt as white as that of European bodies. And the like has been affirmed to me by a phyſician of our own, whom hearing he had diſſected a Negro here in *England*, I conſulted about this particular. The other thing to be here taken notice of concerning Negroes is, that having inquired of an intelligent acquaintance of mine (who keeps in the *Indies* about three hundred of them, as well women as men, to work in his plantations,) whether their children come black into the world; he anſwered, that they did not, but were brought forth of almoſt the like reddiſh colour with our European children: and having further inquired, how long it was before theſe infants appeared black, he replied, that it was not wont to be many days. And agreeable to this account I find that given us in a freſhly publiſhed French book, written by a Jeſuit, that had good opportunity of knowing the truth of what he delivers; for being one of the miſſionaries of his order into the Southern *America* upon the laudable deſign of converting infidels to Chriſtianity, he baptized ſeveral infants, which when newly born were much of the ſame colour with European babes, but within about a week began to appear of the hue of their parents. But more pregnant is the teſtimony of our countryman *Andrew Battel*, who being ſent priſoner by the Portugals to *Angola*, lived there, and in the adjoining regions, partly as a priſoner, partly as a pilot, and partly as a ſoldier, near eighteen years; and he mentioning the *African* kingdom of *Longo*, peopled with Blacks, has this paſſage: *The children in this country are born white, and change their colour in two days to a perfect black.* As for example, *The* Portugals, *which dwell in the kingdom of* Longo, *have ſometimes children by the Negro-women; and many times the fathers are deceived, thinking, when the child is born, that it is theirs, and within two days it proves the ſon or daughter of a Negro, which the Portuga's greatly grieve at.* And the ſame perſon has elſewhere a relation, which, if he have made no uſe at all of the liberty of a traveller, is very well worth our notice; ſince this, together with that we have formerly mentioned of ſeminal impreſſions, ſhews a poſſibility, that a race of Negroes might be begun, though none of the ſons of *Adam* for many precedent generations were of that complexion. For I ſee not, why it ſhould not be at leaſt as poſſible, that white parents may ſometimes have black children, as that African Negroes ſhould ſometimes have laſtingly white ones; eſpecially ſince concurrent cauſes may eaſily more befriend the productions of the former kind, than under the ſcorching heat of *Africa* thoſe of the latter. And I remember on the occaſion of what he delivers, that of the white raven formerly mentioned, the poſſeſſor affirmed to me, that in the neſt, out of which he was taken white, they found with him but one other young one, and that he was of as jetty a black as any common raven. But let us hear our author himſelf: *Here are* (ſays he, ſpeaking of the formerly mentioned regions) *born in this country white children, which is very rare among them, for their parents are Negroes; and when any of them are born, they are preſented to the king, and are called* Dondos; *theſe are as white as any white men. Theſe are the king's witches, and are brought up in witchcraft, and always wait on the king: there is no man, that dares meddle with theſe* Dondos; *if they go to the market, they may take what they liſt, for all men ſtand in awe of them. The king of* Longo *hath four of them.* And yet this country in our globes is placed almoſt in the midſt of the torrid zone, (four or five degrees ſouthward of the line.) And our author elſewhere tells us of the inhabitants, that they are ſo fond of their blackneſs, that they will not ſuffer any, that is not of that colour (as the Portugals that come to trade thither) to be ſo much as buried in their land; of which he annexes a particular example, that may be ſeen in his voyage preſerved by our induſtrious countryman Mr. *Purchas*. But it is high time for me to diſmiſs obſervations, and go on with experiments.

Purchas *Pilgrim, ſecond part, ſeventh Book, Chap. 3. Sect. 5.*

Purchas *ibid.*

Purchas *ibid. in fin.*

EXPERIMENT XII.

THE way, *Pyrophilus*, of producing whiteneſs by chymical precipitations is very well worth our obſerving; for thereby bodies, of very differing colours as well as natures, though diſſolved in ſeveral liquors, are all

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brought into calces or powders that are white. Thus we find, that not only crabs-eyes, that are of themſelves white, and pearls that are almoſt ſo, but coral and minium that are red, being diſſolved in ſpirit of vinegar, may be uniformly precipitated by oil of tartar into white pouders. Thus ſilver and tin ſeparately diſſolved in aqua fortis will the one precipitate it ſelf, and the other be precipitated by common ſalt-water into a white calx, and ſo will crude lead and quickſilver firſt diſſolved likewiſe in aqua fortis. The like calx will be afforded, as I have tried, by a ſolution of that ſhining mineral tin-glaſs diſſolved in aqua fortis, and precipitated out of it; and divers of theſe calces may be made at leaſt as fair and white, if not better coloured, if inſtead of oil of tartar they were precipitated with oil of vitriol, or with another liquor I could name. Nay, that black mineral antimony it ſelf, being reduced by and with the ſalts, that concur to the compoſition of common ſublimate, into that clear though unctuous liquor, that chymiſts commonly call rectified butter of antimony, will, by the bare affuſion of ſtore of fair water, be ſtruck down into that ſnow-white powder, which when the adhering ſaltneſs is well waſhed off, chymiſts are pleaſed to call *Mercurius Vitæ*; though the like powder may be made of antimony, without the addition of any mercury at all. And this lacteſcence, if I may ſo call it, does alſo commonly enſue, when ſpirit of wine, being impregnated with thoſe parts of gums or other vegetable concretions, that are ſuppoſed to abound with ſulphureous corpuſcles, fair water is ſuddenly poured upon the tincture or ſolution. And I remember, that very lately I did, for trial ſake, on a tincture of Benjamin drawn with ſpirit of wine, and brought to be as red as blood, pour ſome fair water; which preſently mingling with the liquor, immediately turned the whole mixture white. But if ſuch ſeeming milks be ſuffered to ſtand unſtirred for a convenient while, they are wont to let fall to the bottom a reſinous ſubſtance, which the ſpirit of wine diluted and weakened by the water poured into it is unable to ſupport any longer. And ſomething of kin to this change of colour in vegetables is that, which chymiſts are wont to obſerve upon the pouring of acid ſpirits upon the red ſolution of ſulphur, diſſolved in an infuſion of pot-aſhes, or in ſome other ſharp lixivium; the precipitated ſulphur, before it ſubſides, immediately turning the red liquor into a white one. And other examples might be added of this way of producing whiteneſs in bodies by precipitating them out of the liquors, wherein they have been diſſolved. But I think it may be more uſeful to admoniſh you, *Pyrophilus*, that this obſervation admits of reſtrictions, and is not ſo univerſal, as by this time perhaps you have begun to think it: for though moſt precipitated bodies are white, yet I know ſome that are not; for gold diſſolved in aqua regis, whether you precipitate it with oil of tartar, or with ſpirit of ſal armoniack, will not afford a white, but a yellow calx. Mercury alſo, though reduced into ſublimate, and precipitated with liquors abounding with volatile ſalts, as the ſpirits drawn from urine, hartſhorn, and other animal ſubſtances, yet will afford, as we noted in our firſt experiment about whiteneſs and blackneſs, a white precipitate; yet with the ſolution of pot-aſhes and other lixiviate ſalts, it will let fall an orange-tawny pouder. And ſo will crude antimony, if being diſſolved in a ſtrong lye, you pour (as far as I remember) any acid liquor upon the ſolution newly filtrated, whilſt it is yet warm. And if upon the filtrated ſolution of vitriol, you pour a ſolution of one of theſe fixed ſalts, there will ſubſide a copious ſubſtance, very far from having any whiteneſs, which the chymiſts are pleaſed to call (how properly I have elſewhere examined,) the ſulphur of vitriol. So that moſt diſſolved bodies being by precipitation brought to white powders, and yet ſome affording precipitates of other colours, the reaſon of both the phænomena may deſerve to be inquired into.

EXPERIMENT XIII.

SOME learned modern writers are of opinion, that the account, upon which whiteneſs and blackneſs ought to be called, as they commonly are, the two extreme colours, is, that blackneſs (by which I preſume is meant the bodies endowed with it) receives no other colours; but whiteneſs very eaſily receives them all: whence ſome of them compare whiteneſs to the *Ariſtotelian Materia prima*, that being capable of any ſort of forms, as they ſuppoſe white bodies to be of every kind of colour. But not to diſpute about names or expreſſions, the thing itſelf, that is affirmed as matter of fact, ſeems to be true enough in moſt caſes, not in all, or ſo as to hold univerſally. For though it be a common obſervation among dyers, that cloaths, which have once been throughly imbued with black, cannot ſo well afterwards be dyed into lighter colours, the pre-exiſtent dark colour infecting the ingredients, that carry the lighter colour to be introduced, and making it degenerate into ſome more ſad one; yet the experiments lately mentioned may ſhew us, that where the change of colour in black bodies is attempted, not by mingling bodies of lighter colours with them, but by addition of ſuch things as are proper to alter the texture of thoſe corpuſcles that contain the black colour, it is no ſuch difficult matter, as the lately mentioned learned men imagine, to alter the colour of black bodies. For we ſaw, that inks of ſeveral kinds might in a trice be deprived of all their blackneſs; and thoſe made with logwood and red-roſes might alſo be changed, the one into a red, the other into a reddiſh liquor; and with oil of vitriol I have ſometimes turned black pieces of ſilk into a kind of yellow; and though the taffaty were thereby made rotten, yet the ſpoiling of that does no way prejudice the experiment, the change of black ſilk into yellow being never the leſs true, becauſe the yellow ſilk is the leſs good. And as for whiteneſs, I think the general affirmation of its being ſo eaſily deſtroyed, or tranſmuted by any other colour, ought

See Scaliger *Exercit.* 325. Sect. 9.

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ought not to be received without ſome cautions and reſtrictions. For whereas, according to what I formerly noted, lead is by calcination turned into that red powder we call minium, and tin by calcination reduced to a white calx; the common putty, that is ſold and uſed ſo much in ſhops, inſtead of being, as it is pretended and ought to be, only the calx of tin, is, by the artificers that make it, to ſave the charge of tin, made (as ſome of themſelves have confeſſed, and as I long ſuſpected by the cheap rate it may be bought for) but of half tin and half lead, if not far more lead than tin; and yet the putty, in ſpite of ſo much lead, is a very white powder, without diſcloſing any mixture of minium. And ſo if you take two parts of copper, which is a high coloured metal, to but one of tin, you may by fuſion bring them into one maſs, wherein the whiteneſs of the tin is much more conſpicuous and predominant than the reddiſhneſs of the copper. And on this occaſion it may not be impertinent to mention an experiment, which I relate upon the credit of a very honeſt man, whom I purpoſely inquired of about it, being my ſelf not very fond of making trials with arſenick: the experiment is this; that if you colliquate arſenick and copper in a due proportion, the arſenick will blanch the copper both within and without, which is an experiment well enough known. But when I inquired, whether or no this white mixture being ſkilfuly kept a while upon the cupel would not let go its arſenick, which made whiteneſs its predominant colour, and return to the reddiſhneſs of copper, I was aſſured of the affirmative. So that among mineral bodies, ſome of thoſe that are white, may be far more capable, than thoſe I am reaſoning with ſeem to have known, of eclipſing others, and of making their colour predominant in mixtures. In further confirmation of which may be added, that I remember, that I alſo took a lump of ſilver and gold melted together, wherein, by the eſtimate of a very experienced refiner, there might be about a fourth or third part of gold; and yet the yellow colour of the gold was ſo hid by the white of the ſilver, that the whole maſs appeared to be but ſilver; and when it was rubbed upon the touch-ſtone, an ordinary beholder could ſcarce have diſtinguiſhed it from the touch of common ſilver; though if I put a little aqua fortis upon any part of the white ſurface it had given the touch-ſtone, the ſilver in the moiſtened part being immediately taken up and concealed by the liquor, the golden particles would preſently diſcloſe that native yellow, and look rather as if gold, than if the above mentioned mixture had been rubbed upon the ſtone.

EXPERIMENT XIV.

I TOOK a piece of black horn, (poliſhed as being part of a comb;) this with a piece of broken glaſs I ſcraped into many thin and curdled flakes, ſome ſhorter and ſome longer; and having laid a pretty quantity of theſe ſcrapings together, I found, as I looked for, that the heap they compoſed was white; and though, if I laid it upon a clean piece of white-paper, its colour ſeemed ſomewhat eclipſed by the greater whiteneſs of the body it was compared with, looking ſomewhat like linen, that had been ſullied by a little wearing; yet if I laid it upon a very black body, as upon a beaver hat, it then appeared to be of a good white. Which experiment, that you may in a trice make when you pleaſe, ſeems very much to diſfavour both their doctrine, that would have colours to flow from the ſubſtantial forms of bodies; and that of the chymiſts alſo, who aſcribe them to one or other of their three hypoſtatical principles: for though in our caſe there was ſo great a change made, that the ſame body, without being ſubſtantially either increaſed or leſſened, paſſes immediately from one extreme colour to another (and that too from black to white) yet this ſo great and ſudden change is effected by a ſlight mechanical tranſpoſition of parts, there being no ſalt or ſulphur or mercury, that can be pretended to be added or taken away, nor yet any ſubſtantial form, that can reaſonably be ſuppoſed to be generated and deſtroyed, the effect proceeding only from a local motion of the parts, which ſo varied their poſition, as to multiply their diſtinct ſurfaces, and to qualify them to reflect far more light to the eye, than they could before they were ſcraped off from the entire piece of black horn.

EXPERIMENT XV.

AND now, *Pyrophilus*, it will not be improper for us to take ſome notice of an opinion touching the cauſe of blackneſs, which I judged it not ſo ſeaſonable to queſtion, till I had ſet down ſome of the experiments, that might juſtify my diſſent from it. You know, that of late divers learned men, having adopted the three hypoſtatical principles, beſides other notions of the chymiſts, are very inclinable to reduce all qualities of bodies to one or other of thoſe three principles; and particularly aſſign for the cauſe of blackneſs the ſooty ſteam of aduſt or torrified ſulphur. But I hope, that what we have delivered above to countenance the opinion we have propoſed about the cauſe of blackneſs, will ſo eaſily ſupply you with ſeveral particulars, that may be made uſe of againſt this opinion, that I ſhall now repreſent to you but two things concerning it.

AND firſt, it ſeems, that the favourers of the chymical theories might have pitcht upon ſome more proper term, to expreſs the efficient of blackneſs than ſulphur aduſt; for we know, that common ſulphur, not only when melted, but even when ſublimed, does not grow black by ſuffering the action of the fire, but continues and aſcends yellow, and rather more than leſs white, than it was before its being expoſed to the fire. And if it be ſet on fire, as when we make that acid liquor, that chymiſts call *Oleum Sulphuris per campanam*, it affords very little ſoot; and indeed the flame yields ſo little, that it will ſcarce in any degree black a ſheet of white

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white paper, held a pretty while over the flame and ſmoke of it, which is obſerved rather to whiten than infect linen, and which does plainly make red roſes grow very pale, but not at all black, as far as the ſmoke is permitted to reach the leaves. And I can ſhew you a ſort of fixt ſulphur made by an induſtrious laborant of your acquaintance, who aſſured me, that he was wont to keep it for divers weeks together night and day in a naked and violent fire, almoſt like that of the glaſs-houſe; and when, to ſatisfy my curioſity, I made him take out a lump of it, though it were glowing hot (and yet not melted) it did not, when I had ſuffered it to cool, appear black, the true colour of it being a true red. I know it may be ſaid, that chymiſts in the opinion above recited mean the principle of ſulphur, and not common ſulphur, which receives its name, not from its being all perfectly of a ſulphureous nature, but for that plenty and predominancy of the ſulphureous principle in it. But allowing this, it is eaſy to reply, that according to this very reaſon, torrified ſulphur ſhould afford more blackneſs than moſt other concretes, wherein that principle is confeſſed to be far leſs copious. Alſo when I have expoſed camphire to the fire in cloſe veſſels, as inflammable, and conſequently (according to the chymiſts) as ſulphureous a body as it is, I could not by ſuch a degree of heat as brought it to fuſion, and made it boil in the glaſs, impreſs any thing of blackneſs, or of any other colour, than its own pure white, upon this vegetable concrete. But what ſhall we ſay to ſpirit of wine, which being made by a chymical analyſis of the liquor that affords it, and being totally inflammable, ſeems to have a full right to the title they give it of *Sulphur Vegetabile?* and yet this fluid ſulphur not only contracts not any degree of blackneſs by being often ſo heated, as to be made to boil, but when it burns away with an actual flame, I have not found, that it would diſcolour a piece of white paper held over it, with any diſcernable ſoot. Tin alſo, that wants not, according to the chymiſts, a *Sulphur Joviale*, when throughly burned by the fire into a calx, is not black, but eminently white. And I lately noted to you out of *Bellonius*, that the charcoals of Oxy-cedar are not of the former of theſe two colours, but of the latter. And the ſmoke of our *Tinby* coals here in *England* has been uſually obſerved rather to blanch linen than to black it. To all which other particulars of the like nature might be added; but I rather chuſe to put you in mind of the third experiment, about making black liquors, or ink, of bodies, that were none of them black before. For how can it be ſaid, that when thoſe liquors are put together actually cold, and continue ſo after their mixture, there intervenes any new aduſtion of ſulphur to produce the emergent blackneſs? (and the ſame queſtion will be applicable to the blackneſs produced upon the blade of a knife, that has cut lemons and ſome kind of ſour apples, if the juice, though both actually and potentially cold, be not quickly wiped off.) And when by the inſtilling either of a few drops of oil of vitriol, as in the ſecond experiment, or of a little of the liquor mentioned in the paſſage pointed at in the fourth experiment, (where I teach at once to deſtroy one black ink, and make another) the blackneſs produced by thoſe experiments is preſently deſtroyed; if the colour proceeded only from the plenty of ſulphurous parts, torrified in the black bodies, I demand what becomes of them, when the colour ſo ſuddenly diſappears? For it cannot reaſonably be ſaid, that all thoſe, that ſufficed to make ſo great a quantity of black matter, ſhould reſort to ſo very ſmall a proportion of the clarifying liquor, (if I may ſo call it) as to be diluted by it, without at all denigrating it. And if it be ſaid, that the inſtilled liquor diſperſed thoſe black corpuſcles, I demand, how that diſperſion comes to deſtroy their blackneſs, but by making ſuch a local motion of their parts, as deſtroys their former texture? Which may be a matter of ſuch moment in caſes like ours, that I remember, that I have in few hours, without addition, from ſoot it ſelf, attained pretty ſtore of cryſtalline ſalt, and good ſtore of tranſparent liquor; and (which I have on another occaſion noted as remarkable) this ſo black ſubſtance had its colour ſo altered, by the change of texture it received from the fire, wherewith it was diſtilled, that it did for a great while afford ſuch plenty of very white exhalations, that the receiver, though large, ſeemed to be almoſt filled with milk.

SECONDLY, But were it granted, as it is in ſome caſes not improbable, that divers bodies may receive a blackneſs from a ſooty exhalation, occaſioned by the aduſtion of their ſulphur, which (for the reaſons lately mentioned) I ſhould rather call their oily parts; yet ſtill this account is applicable but to ſome particular bodies, and will afford us no general theory of blackneſs. For if, for example, white hartſhorn being, in veſſels well luted to each other, expoſed to the fire, be ſaid to turn black by the infection of its own ſmoke, I think I may juſtly demand, what it is that makes the ſmoke or ſoot it ſelf black, ſince no ſuch colour, but its contrary, appeared before in the hartſhorn? And with the ſame reaſon, when we are told, that torrified ſulphur makes bodies black, I deſire to be told alſo, why torrefaction makes ſulphur it ſelf black? Nor will there be any ſatisfactory reaſon aſſigned of theſe queries, without taking in thoſe fertile as well as intelligible mechanical principles of the poſition and texture of the minute parts of the body in reference to the light and the eye; and theſe applicable principles may ſerve the turn in many caſes, where the aduſtion of ſulphur cannot be pretended; as in the appearing blackneſs of an open window lookt upon at a ſomewhat remote diſtance from the houſe; as alſo in the blackneſs men think they ſee in the holes, that happen to be in white linen, or paper of the like colour; and in the increaſing blackneſs immediately produced barely by ſo rubbing velvet, whoſe piles were inclined before, as to reduce them

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them to a more erected poſture; in which and in many other caſes formerly alledged, there appears nothing requiſite to the production of the blackneſs, but the hindering of the incident beams of light from rebounding plentifully enough to the eye. To be ſhort; thoſe I reaſon with, do concerning blackneſs what the chymiſts are wont alſo to do concerning other qualities; namely, to content themſelves to tell us, in what ingredient of a mixt body, the quality inquired after does reſide, inſtead of explicating the nature of it, which (to borrow a compariſon from their own laboratories) is much as if in an inquiry after the cauſe of ſalivation, they ſhould think it enough to tell us, that the ſeveral kinds of precipitates of gold and mercury, as likewiſe of quickſilver and ſilver (for I know the make and uſe of ſuch precipitates alſo) do ſalivate upon the account of the mercury, which though diſguiſed abounds in them; whereas the difficulty is as much to know upon what account mercury it ſelf, rather than other bodies, has that power of working by ſalivation. Which I ſay not, as though it were not ſomething (and too often the moſt we can arrive at) to diſcover in which of the ingredients of a compounded body the quality, whoſe nature is ſought, reſides; but becauſe, though this diſcovery it ſelf may paſs for ſomething, and is oftentimes more than what is taught us about the ſame ſubjects in the ſchools, yet we ought not to think it enough, when more clear and particular accounts are to be had.

The Experimental Hiſtory of COLOURS *begun.*

PART III.

Containing promiſcuous Experiments about COLOURS.

EXPERIMENT I.

BECAUSE that, according to the conjectures I have above propoſed, one of the moſt general cauſes of the diverſity of colours in opacous bodies, is, that ſome reflect the light mingled with more, others with leſs of ſhade, (either as to quantity, or as to interruption;) I hold it not unfit to mention, in the firſt place, the experiments, that I thought upon to examine this conjecture. And though coming to tranſcribe them out of ſome phyſiological *Adverſaria* I had written in looſe papers, I cannot find one of the chief records I had of my trials of this nature, yet the papers, that ſcaped miſcarrying, will, I preſume, ſuffice to manifeſt the main thing, for which I now alledge them. I find then among my *Adverſaria* the following narrative.

October the 11th, About ten in the morning in ſun-ſhiny weather, (but not without fleeting clouds) we took ſeveral ſorts of paper ſtained, ſome of one colour, and ſome of another; and in a darkened room, whoſe window looked ſouthward, we caſt the beams, that came in at a hole about three inches and a half in a diameter, upon a white wall, that was placed on one ſide, about five foot diſtance from them.

THE white gave much the brighteſt reflection.

THE green, red, and blue being compared together, the red gave much the ſtrongeſt reflection, and manifeſtly enough alſo threw its colour upon the wall: the green and blue were ſcarce diſcernable by their colours, and ſeemed to reflect an almoſt equal light.

THE yellow, compared with the two laſt named, reflected ſomewhat more light.

THE red and purple being compared together, the former manifeſtly reflected a good deal more light.

THE blue and purple compared together, the former ſeemed to reflect a little more light, though the purple colour were more manifeſtly ſeen.

A SHEET of very well ſleeked marbled paper being applied as the others, did not caſt any of its diſtinct colours upon the wall, nor throw its light upon it with an equal diffuſion; but threw the beams unſtained and bright to this and that part of the wall, as if its poliſh had given it the nature of a ſpecular body. But comparing it with a ſheet of white paper, we found the reflection of the latter to be much ſtronger, it diffuſing almoſt as much light to a good extent as the marble paper did to one part of the wall.

THE green and purple left us ſomewhat in ſuſpenſe, which reflected the moſt light; only the purple ſeemed to have ſome little advantage over the green, which was dark in its kind.

THUS much I find in our above mentioned collections; among which there are alſo ſome notes concerning the production of compounded colours, by reflection from bodies differingly coloured. And theſe notes we intended ſhould ſupply us with what we ſhould mention as our ſecond experiment: but having loſt the paper, that contained the particulars, and remembering only in general, that if the objects, which reflected the light, were not ſtrongly coloured and ſomewhat gloſſy, the reflected beams would not manifeſtly make a compounded colour upon the wall, and even then but very faintly; we ſhall now ſay no more of that matter, only reſerving our ſelves to mention hereafter the compoſition of a green, which we ſtill retain in memory.

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EXPERIMENT II.

WE may add, *Pyrophilus*, on this occaſion, that though a darkened room be generally thought requiſite to make the colour of a body appear by reflection from another body, that is not one of thoſe, that are commonly agreed upon to be ſpecular, (as poliſhed metal, quickſilver, glaſs, water, *&c.*) yet I have often obſerved, that when I wore doublets lined with ſome ſilken ſtuff, that was very gloſſy and vividly coloured, eſpecially red, I could in an enlightened room plainly enough diſcern the colour upon the pure white linen, that came out at my ſleeve, and reached to my cuffs; as if that fine white body were more ſpecular than coloured and unpoliſhed bodies are thought capable of being.

EXPERIMENT III.

WHILST we were making the newly mentioned experiments, we thought fit to try alſo what compoſition of colours might be made by altering the light in its paſſage to the eye, by the interpoſition not of perfectly diaphanous bodies (that having been already tried by others as well as by us, as we ſhall ſoon have occaſion to take notice) but of ſemi-opacous bodies, and thoſe ſuch as looked upon in an ordinary light, and not held betwixt it and the eye, are not wont to be diſcriminated from the reſt of opacous bodies. Of this trial our mentioned *Adverſaria* preſent us the following account:

HOLDING theſe ſheets, ſometimes one, ſometimes the other of them, before the hole betwixt the ſun and the eye, with the coloured ſides obverted to the ſun; we found them ſingle to be ſomewhat tranſparent, and appear of the ſame colour as before, only a little altered by the great light they were placed in: but laying two of them one over another, and applying them ſo to the hole, the colours were compounded as follows.

THE blue and yellow ſcarce exhibited any thing but a darker yellow, which we aſcribed to the coarſeneſs of the blue paper, and its darkneſs in its kind. For applying the blue parts of the marbled paper with the yellow paper after the ſame manner, they exhibited a good green.

THE yellow and red looked upon together gave us but a dark red, ſomewhat (and but a little) inclining to an orange colour.

THE purple and red looked on together appeared more ſcarlet.

THE purple and yellow made an orange.

THE green and red made a dark orange-tawny.

THE green and purple made the purple appear more dirty.

THE blue and purple made the purple more lovely, and far more deep.

THE red parts of the marbled paper, looked upon with the yellow, appeared of a red far more like ſcarlet than without it.

BUT the fineneſs or coarſeneſs of the papers, their being carefully or ſlightly coloured, and divers other circumſtances, may ſo vary the events of ſuch experiments as theſe, that if, *Pyrophilus*, you would build much on them, you muſt carefully repeat them.

EXPERIMENT IV.

THE triangular priſmatical glaſs being the inſtrument, upon whoſe effects we may the moſt commodiouſly ſpeculate the nature of emphatical colours, (and perhaps that of others too;) we thought it might be uſeful to obſerve the ſeveral reflections and refractions, which the incident beams of light ſuffer in rebounding from it, and paſſing through it. And this we thought might be beſt done, not (as is uſual) in an ordinary enlightened room, where (by reaſon of the difficulty of doing otherwiſe) even the curious have left particulars unheeded, which may in a convenient place be eaſily taken notice of; but in a darkened room, where by placing the glaſs in a convenient poſture, the various reflections and refractions may be diſtinctly obſerved; and where it may appear, what beams are untinged, and which they are, that, upon the bodies, that terminate them, do paint either the primary or ſecondary iris. In purſuance of this we did, in the abovementioned darkened room, make obſervation of no leſs than four reflections, and three refractions, that were afforded us by the ſame priſm; and thought, that, notwithſtanding what was taught us by the rules of catoptricks and dioptricks, it would not be amiſs to find alſo, by hiding ſometimes one part of the priſm, and ſometimes another, and obſerving where the light or colour vaniſhed thereupon, by which reflection and by which refraction each of the ſeveral places whereon the light rebounding from, or paſſing through, the priſm, appeared either ſincere or tincted, was produced. But becauſe it would be tedious, and not ſo intelligible to deliver this in words, I have thought fit to refer you to the annexed ſcheme, where the newly mentioned particulars may be at one view taken notice of.

EXPERIMENT V.

I KNOW not whether you will think it inconſiderable to annex to this experiment, that we obſerved in a room not darkened, that the priſmatical iris (if I may ſo call it) might be reflected without loſing any of its ſeveral colours (for we now conſider not their order) not only from a plain looking-glaſs and from the calm ſurface of fair water, but alſo from a concave looking-glaſs; and that refraction did as little deſtroy thoſe colours as reflection. For by the help of a large (double convex) burning-glaſs, through which we refracted the ſunbeams, we found, that one part of the iris might be made to appear either beyond, or on this ſide of the other parts of the ſame iris; but yet the ſame vivid colours would appear in the diſplaced part (if I may ſo term it) as in the other. To which I ſhall add, that having, by hiding the ſide of the priſm, obverted to

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to the ſun with an opacous body, wherein only one ſmall hole was left for the light to paſs through, reduced the priſmatical iris (caſt upon white paper) into a very narrow compaſs, and looked upon it through a microſcope; the colours appeared the ſame as to kind, that they did to the naked eye.

EXPERIMENT VI.

IT may afford matter of ſpeculation to the inquiſitive, ſuch as you, *Pyrophilus*, that as the colours of outward objects brought into a darkened room do ſo much depend for their viſibility upon the dimneſs of the light they are there beheld by, that the ordinary light of the day being freely let in upon them, they immediately diſappear; ſo our trials have informed us, that as to the priſmatical iris painted on the floor by the beams of the ſun trajected thorough a triangular glaſs, though the colours of it appear very vivid even at noon-day, and in ſhun-ſhiny weather, yet by a more powerful light they may be made to diſappear. For having ſometimes, (in proſecution of ſome conjectures of mine not now to be inſiſted on) taken a large metalline concave ſpeculum, and with it caſt the converging beams of the ſun upon a priſmatical iris, which I had cauſed to be projected upon the floor, I found, that the over-powerful light made the colours of the iris diſappear. And if I ſo reflected the light, as that it croſſed but the middle of the iris, in that part only the colours vaniſhed or were made inviſible; thoſe parts of the iris, that were on the right and left hand of the reflected light (which ſeemed to divide them, and cut the iris aſunder) continuing to exhibit the ſame colours as before. But upon this we muſt not now ſtay to ſpeculate.

EXPERIMENT VII.

I HAVE ſometimes thought it worth while to take notice, whether or no the colours of opacous bodies might not appear to the eye ſomewhat diverſified, not only by the diſpoſition of the ſuperficial parts of the bodies themſelves, and by the poſition of the eye in reference to the object and the light, (for theſe things are notorious enough;) but according alſo to the nature of the lucid body, that ſhines, upon them. And I remember, that in proſecution of this curioſity, I obſerved a manifeſt difference in ſome kinds of coloured bodies looked on by day-light, and afterwards by the light of the moon, either directly falling on them, or reflected upon them from a concave looking-glaſs. But not finding at preſent, in my collections about colours, any thing ſet down of this kind, I ſhall, till I have opportunity to repeat them, content myſelf to add what I find regiſtered concerning colours looked on by candle-light, in regard that not only the experiment is more eaſy to be repeated, but the objects being the ſame ſorts of coloured paper laſtly mentioned, the collation of the two experiments may help to make the conjectures they will ſuggeſt ſomewhat the leſs uncertain.

WITHIN a few days of the time above mentioned, divers ſheets of coloured paper, that had been looked upon before in the ſun-ſhine, were looked upon at night by the light of a pretty big candle (ſnuffed;) and the changes that were obſerved were theſe:

THE yellow ſeemed much fainter than in the day, and inclinable to a pale ſtraw-colour.

THE red ſeemed little changed; but ſeemed to reflect light more ſtrongly than any other colour, (for white was none of them.)

A FAIR deep green looked upon by it ſelf, ſeemed to be a dark blue: but being looked upon together with a dark blue, appeared greeniſh; and beheld together with a yellow, appeared more blue than at firſt.

THE blue looked more like a deep purple or murray, than it had done in the day-light.

THE purple ſeemed very little altered.

THE red looked upon with the yellow made the yellow look almoſt like brown cap-paper.

N. B. THE caution ſubjoined to the third experiment is alſo applicable to this.

EXPERIMENT VIII.

BUT here I muſt not omit to ſubjoin, that to ſatisfy our ſelves, whether or no the light of a candle were not made unſincere, and as it were tinged with a yellow colour, by the admixtion of the corpuſcles it aſſumes from its fuel; we did not content ourſelves with what appears to the naked eye, but taking a pretty thick rod or cylinder (for thin pieces would not ſerve the turn) of deep blue glaſs, and looking upon the candle's flame at a convenient diſtance through it, we perceived, as we expected, the flame to look green: which, as we often note, is the colour wont to emerge from the compoſition of opacous bodies, which were apart one of them blue, and the other yellow. And this perchance may be the main reaſon of that, which ſome obſerve, that a ſheet of very white paper being looked upon by candle-light, it is not eaſy at firſt to diſcern it from a light yellow or lemon colour; white bodies (as we have elſewere obſerved) having more than thoſe, that are otherwiſe coloured, of a ſpecular nature; in regard that though they exhibit not (unleſs they be poliſhed) the ſhape of the luminary, that ſhines on them, yet they reflect its light more ſincere and untroubled, by either ſhades or refractions, than bodies of other colours, (as blue, or green, or yellow, or the like.)

EXPERIMENT IX.

WE took a leaf of ſuch foliated gold, as apothecaries are wont to gild their pills with; and with the edge of a knife, (lightly moiſtened by drawing it over the ſurface of the tongue, and afterwards) laid upon the edge of the gold leaf, we ſo faſtened it to the knife, that being held againſt the light, it continued extended like a little flag. This leaf being held

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very near the eye, and obverted to the light, appeared ſo full of pores, that it ſeemed to have ſuch a kind of tranſparency, as that of a ſieve, or a piece of cypreſs, or a love-hood; but the light that paſſed by theſe pores was in its paſſages ſo tempered with ſhadow, and modified, that the eye diſcerned no more a golden colour, but a greeniſh blue. And for others ſatisfaction, we did in the night look upon a candle through ſuch a leaf of gold; and by trying the effect of ſeveral proportions of diſtance betwixt the leaf, the eye and the light, we quickly hit upon ſuch a poſition for the leaf of gold, as that the flame, looked on through it, appeared of a greeniſh blue, as we have ſeen in the day-time. The like experiment tried with a leaf of ſilver ſucceeded not well.

EXPERIMENT X.

WE have have ſometimes found in the ſhops of our druggiſts a certain wood, which is there called *Lignum Nephriticum*, becauſe the inhabitants of the country, where it grows, are wont to uſe the infuſion of it made in fair water againſt the ſtone of the kidneys. And indeed an eminent phyſician of our acquaintance, who has very particularly inquired into that diſeaſe, aſſures me, that he has found ſuch an infuſion one of the moſt effectual remedies, which he has ever tried againſt that formidable diſeaſe. The ancienteſt account I have met with of this ſimple, is given us by the experienced *Monardes* in theſe words: *Nobis*, ſays he, *Nova Hiſpania mittit quoddam ligni genus craſſum & enode, cujus uſus jam diu receptus fuit in his regionibus ad renum vitia, & urinæ difficultates ac arenulas pellendas. Fit autem hac ratione; lignum aſſulatim & minutim conciſum in limpidiſſima aqua fontana maceratur, inque ea relinquitur, donec aqua à bibentibus abſumpta ſit; dimidia hora poſt injectum lignum aqua cæruleum colorem contrahit, qui ſenſim intenditur pro temporis diuturnitate, tametſi lignum candidum ſit.* This wood, *Pyrophilus*, may afford us an experiment, which, beſides the ſingularity of it, may give no ſmall aſſiſtance to an attentive conſiderer towards the detection of the nature of colours. The experiment, as we made it, is this: Take *Lignum Nephriticum*, and with a knife cut it into thin ſlices; put about a handful of theſe ſlices into two, three or four pound of the pureſt ſpring-water; let them infuſe there a night; but if you be in haſte, a much ſhorter time may ſuffice. Decant this impregnated water into a clear glaſs phial; and if you hold it directly betwen the light and your eye, you ſhall ſee it wholly tincted, (excepting the very top of the liquor, wherein you will ſometimes diſcern a ſky-coloured circle) with an almoſt golden colour, unleſs your infuſion have been made too ſtrong of the wood; for in that caſe it will againſt the light appear ſomewhat dark and reddiſh, and requires to be diluted by the addition of a convenient quantity of water. But if you hold this phial from the light, ſo that your eye be placed betwixt the window and the phial, the liquor will appear of a deep and lovely ceruleous colour, of which alſo the drops, if any be lying on the outſide of the glaſs, will ſeem to be very perfectly. And thus far we have tried the experiment, and found it to ſucceed even by the light of candles of the larger ſize. If you ſo hold the phial over againſt your eyes, that it may have a window on one ſide of it, and a dark part of the room both before it and on the other ſide, you ſhall ſee the liquor partly of a blueiſh and partly of a golden colour. If turning your back to the window, you pour out ſome of the liquor towards the light and towards your eyes, it will ſeem at the coming out of the glaſs to be perfectly ceruleous; but when it is fallen down a little way, the drops may ſeem particoloured, according as the beams of light do more or leſs fully penetrate and illuſtrate them. If you take a baſon about half full of water, and having placed it ſo in the ſun-beams ſhining into a room, that one part of the water may be freely illuſtrated by the beams of light, and the other part of it darkned by the ſhadow of the brim of the baſon; if then, I ſay, you drop of our tincture, made ſomewhat ſtrong, both into the ſhaded and illuminated parts of the water, you may by looking upon it from ſeveral places, and by a little agitation of the water, obſerve divers pleaſing phænomena, which were tedious to particularize. If you pour a little of this tincture upon a ſheet of white paper, ſo as the liquor may remain of ſome depth upon it, you may perceive the neighbouring drops to be partly of one colour, and partly of the other, according to the poſition of your eye in reference to the light when it looks upon them; but if you pour off the liquor, the paper will ſeem dyed of an almoſt yellow colour. And if a ſheet of paper with ſome of this liquor in it be placed in a window where the ſun-beams may ſhine freely on it, then if you turn your back to the ſun and take a pen or ſome ſuch ſlender body, and hold it over-thwart betwixt the ſun and the liquor, you may perceive, that the ſhadow projected by the pen upon the liquor will not all of it be a vulgar and dark, but in part a curiouſly coloured ſhadow; that edge of it, which is next the body that makes it, being almoſt of a lively golden colour, and the remoter verge of a ceruleous one.

Nicolaus Monardes lib. *ſimplic. ex India allator.* cap. 27.

THESE and other phænomena, which I have obſerved in this delightful experiment, divers of my friends have looked upon not without ſome wonder; and I remember an excellent oculiſt, finding by accident in a friend's chamber a fine phial full of this liquor, which I had given that friend, and having never heard any thing of the experiment, nor having any body near him, that could tell him what this ſtrange liquor might be, was a great while apprehenſive, as he preſently after told me, that ſome ſtrange new diſtemper was invading his eyes. And I confeſs, that the unuſualneſs of the phænomena made me very ſollicitous to find out the cauſe of this experiment; and though I am far from pretending to have found it, yet my inquiries have, I ſuppoſe, enabled me to give

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give ſuch hints, as may lead your greater ſagacity to the diſcovery of the cauſe of this wonder. And firſt finding that this tincture, if it were too copious in the water, kept the colours from being ſo lively, and their change from being ſo diſcernable, and finding alſo that the impregnating virtue of this wood did by its being frequently infuſed in new water by degrees decay; I conjectured that the tincture afforded by the wood muſt proceed from ſome ſubtiler parts of it drawn forth by the water, which ſwimming to and fro in it, did ſo modify the light, as to exhibit ſuch and ſuch colours: and becauſe theſe ſubtile parts were ſo eaſily ſoluble even in cold water, I concluded that they muſt abound with ſalts, and perhaps contain much of the eſſential ſalt, as the chymiſts call it, of the wood. And to try whether theſe ſubtile parts were volatile enough to be diſtilled, without the diſſolution of their texture, I carefully diſtilled ſome of the tincted liquor in very low veſſels, and the gentle heat of a lamp furnace; but found all that came over to be as limpid and colourleſs as rock-water, and the liquor remaining in the veſſel to be ſo deeply ceruleous, that it required to be oppoſed to a very ſtrong light to appear of any other colour. I took likewiſe a phial with ſpirit of wine, and a little ſalt of hartſhorn, and found that there was a certain proportion to be met with betwixt the liquor and the ſalt, which made the mixture fit to exhibit ſome little variety of colours not obſervable in ordinary liquors, as it was variouſly directed in reference to the light and the eye; but this change of colour was very far ſhort from that which we had admired in our tincture. But however, I ſuſpected that the tinging particles did abound with ſuch ſalts, whoſe texture, and the colour ſpringing from it, would probably be altered by piercing acid ſalts, which would in likelihood either make ſome diſſipation of their parts, or aſſociate themſelves to the like bodies, and either way alter the colour exhibited by them; whereupon pouring into a ſmall phial, full of impregnated water, a very little ſpirit of vinegar, I found that, according to my expectation, the ceruleous colour immediately vaniſhed, but was deceived in the expectation I had, that the golden colour would do ſo too; for, which way ſoever I turned the phial, either to or from the light, I found the liquor to appear always of a yellowiſh colour and no other. Upon this I imagined that the acid ſalts of the vinegar having been able to deprive the liquor of its ceruleous-colour, a ſulphureous ſalt being of a contrary nature, would be able to mortify the ſaline particles of vinegar, and deſtroy their effects; and accordingly having placed my ſelf betwixt the window, and the phial, and into the ſame liquor dropt a few drops of oil of tartar *per deliquium*, (as chymiſts call it) I obſerved with pleaſure, that immediately upon the diffuſion of this liquor, the impregnated water was reſtored to its former ceruleous colour; and this liquor of tartar being very ponderous, and falling at firſt to the bottom of the phial, it was eaſy to obſerve that for a little while the lower part of the liquor appeared deeply ceruleous, whilſt all the upper part retained its former yellowneſs, which it immediately loſt as ſoon as either agitation or time had made a competent diffuſion of the liquor of tartar through the body of the former tincture; and this reſtored liquor did, as it was looked upon againſt or from the light, exhibit the ſame phænomena as the tincted water did, before either of the adventitious liquors was poured into it.

HAVING made, *Pyrophilus*, divers trials upon this nephritick wood, we found mention made of it by the induſtrious Jeſuit *Kircherus*, who having received a cup turned of it from the Mexican procurator of his ſociety, has probably received alſo from him the information he gives us concerning that exotick plant; and therefore partly for that reaſon, and partly becauſe what he writes concerning it, does not perfectly agree with what we have delivered, we ſhall not ſcruple to acquaint you in his own words, with as much of what he writes concerning our wood, as is requiſite to our preſent purpoſe. *Hoc loco* (ſays he) *neutiquam omittendum duximus quoddam ligni candidi Mexicani genus, quod indigenæ Coalle & Tlapazatli vocant, quod etſi experientia hucuſque non niſi cæruleo aquam colore tingere docuerit, nos tamen continua experientia invenimus id aquam in omne colorum genus transformare, quod merito cuipiam paradoxum videri poſſet; ligni frutex grandis, ut aiunt, non rarò in molem arboris excreſcit, truncus illius eſt craſſus, enodis, inſtar piri arboris, folia ciceris foliis, aut rutæ haud abſimilia, flores exigui, oblongi, lutei & ſpicatim digeſti; eſt frigida & humida planta, licet parum recedat à medio temperamento. Hujus itaque deſcriptæ arboris lignum in poculum efformatum, aquam eidem infuſam primo in aquam intenſe cæruleam, colore floris bugloſſæ, tingit, & quo diutius in eo ſteterit, tanto intenſiorem colorem acquirit. Hanc igitur aquam ſi vitriæ ſphæræ infuderis, lucique expoſueris, ne ullum quidem cærulei coloris veſtigium apparebit, ſed inſtar aquæ puræ putæ fontanæ limpidam claramque aſpicientibus ſe præbebit. Porro ſi hanc phialam vitream verſus locum magis umbroſum direxeris, totus humor gratiſſimum virorem referet; ſi adhuc umbroſioribus locis, ſubrubrum, & ſic pro rerum objectarum conditione, mirum dictu, colorem mutabit; in tenebris verò vel in vaſe opaco poſita, cæruleum colorem ſuum reſumet.* Kircher. Art. Magn. lucis & umbræ, lib. 1. part. 3.

IN this paſſage we may take notice of the following particulars. And firſt, he calls it a white Mexican wood, whereas (not to mention that *Monardes* informs us that it is brought out of *Nova Hiſpania*) the wood that we have met with in ſeveral places, and employed as *Lignum Nephriticum*, was not white, but for the moſt part of a much darker colour, not unlike that of the ſadder coloured wood of juniper. It is true, that *Monardes* himſelf alſo ſays, that the wood is white; and it is affirmed, that the wood which is of a ſadder colour is adulterated by being imbued with the tincture of a vegetable, in whoſe decoction it is ſteeped. But having purpoſely inquired of the eminenteſt of our Engliſh druggiſts, he peremptorily

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emptorily denied it. And indeed, having conſidered ſome of the faireſt round pieces of this wood that I could meet with in theſe parts, I had opportunity to take notice that in one or two of them it was the external part of the wood that was white, and the more inward part that was of the other colour; the contrary of which would probably have appeared, if the wood had been adulterated after the aforementioned manner. And I have at preſent by me a piece of ſuch wood, which for about an inch next the bark is white, and then, as it were, abruptly paſſes to the abovementioned colour; and yet this wood, by the tincture it afforded us in water, appears to have its coloured part genuine enough: for as for the white part, it appears, upon trial of both at once, much leſs enriched with the tingent property.

NEXT, whereas our author tells us, that the infuſion of this wood expoſed in a phial to the light, looks like ſpring-water, in which, he afterwards adds, that there is no tincture to be ſeen in it; our obſervation and his agree not: for the liquor which oppoſed to the darker part of a room exhibits a ſky-colour, did conſtantly, when held againſt the light, appear yellowiſh or reddiſh, according as its tincture was more dilute or deep; and then, whereas it has been already ſaid, that the ceruleous colour was by acid ſalts aboliſhed, this yellowiſh one ſurvived without any conſiderable alteration, ſo that unleſs our author's words be taken in a very limited ſenſe, we muſt conclude, that either his memory miſinformed him, or that his white nephritick wood, and the ſadder coloured one which we employed, were not altogether of the ſame nature. What he mentions of the cup made of *Lignum Nephriticum*, we have not had opportunity to try, not having been able to procure pieces of that wood great enough, and otherwiſe fit to be turned into cups; but as for what he ſays in the title of his experiment, that this wood tinges the water with all ſorts of colours, that is much more than any of thoſe pieces of nephritick wood that we have hitherto employed, was able to make good; the change of colours diſcernable in a phial full of water, impregnated by any of them, as it is directed towards a place more lightſome or obſcure, being far from affording a variety anſwerable to ſo promiſing a title. And as for what he tells us, that in the dark the infuſion of our wood will reſume a ceruleous colour, I wiſh he had informed us how he tried it.

BUT this brings into my mind, that having ſometimes, for curioſity ſake, brought a round phial with a long neck filled with the tincture of *Lignum Nephriticum* into the darkened room already often mentioned, and holding it ſometimes in, ſometimes near the ſun-beams that entered at the hole, and ſometimes partly in them, and partly out of them, the glaſs being held in ſeveral poſtures, and looked upon from ſeveral neighbouring parts of the room, diſcloſed a much greater variety of colours than in ordinary enlightened rooms it is wont to do; exhibiting, beſides the uſual colours, a red in ſome parts, and a green in others, beſides intermediate colours produced by the differing degrees, and odd mixtures of light and ſhade.

BY all this you may ſee, *Pyrophilus*, the reaſonableneſs of what we elſewhere had occaſion to mention, when we have divers times told you, that it is uſeful to have new experiments tried over again, though they were, at firſt, made by knowing and candid men; ſuch reiterations of experiments commonly exhibiting ſome new phænomena, detecting ſome miſtake or hinting ſome truth, in reference to them, that was not formerly taken notice of. And ſome of our friends have been pleaſed to think, that we have made no unuſeful addition to this experiment, by ſhewing a way, how in a moment our liquor may be deprived of its blueneſs, and reſtored to it again by the affuſion of a few drops of liquors, which have neither of them any colour at all of their own. And that which deſerves ſome particular wonder, is, that the ceruleous tincture of our wood is ſubject by the former method to be deſtroyed or reſtored, the yellowiſh or reddiſh tincture continuing what it was. And that you may ſee, that ſalts are of a conſiderable uſe in the ſtriking of colours, let me add to the many experiments which may be afforded us to this purpoſe by the dyers trade, this obſervation; that as far as we have hitherto tried, thoſe liquors in general that are ſtrong of acid ſalts have the power of deſtroying the blueneſs of the infuſion of our wood, and thoſe liquors indiſcriminately that abound with ſulphureous ſalts (under which I comprehend the urinous and volatile ſalts of animal ſubſtances, and the alcalizate or fixed ſalts that are made by incineration) have the virtue of reſtoring it.

A Corollary of the TENTH EXPERIMENT.

THAT this experiment, *Pyrophilus*, may be as well uſeful as delightful to you, I muſt mind you, *Pyrophilus*, that in the newly mentioned obſervation, I have hinted to you a new and eaſy way of diſcovering in many liquors (for I dare not ſay in all) whether it be an acid or ſulphureous ſalt, that is predominant; and that ſuch a diſcovery is oftentimes of great difficulty, and may frequently be of great uſe, he that is not a ſtranger to the various properties and effects of ſalts, and of how great moment it is to be able to diſtinguiſh their tribes, may readily conceive. But to proceed to the way of trying other liquors by an infuſion of our wood, take it briefly thus. Suppoſe I have a mind to try whether I conjecture aright, when I imagine that allom, though it be plainly a mixt body, does abound rather with acid than ſulphureous ſalt: To ſatisfy my ſelf herein, I turn my back to the light, and holding a ſmall phial full of the tincture of *Lignum Nephriticum*, which, looked upon in that poſition, appears ceruleous, I drop into it a little of a ſtrong ſolution of allom made in fair water; and finding upon the affuſion and ſhaking of this new liquor, that the blueneſs formerly conſpicuous on our tincture does preſently vaniſh, I am thereby incited to ſuppoſe, that the ſalt predominant in allom

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allom belongs to the family of four ſalts. But if on the other ſide I have a mind to examine whether or no I rightly conceive that ſalt of urine, or of hartſhorn is rather of a ſaline ſulphureous (if I may ſo ſpeak) than of an acid nature, I drop a little of the ſaline ſpirit of either into the nephritick tincture, and finding that the ceruleous colour is rather thereby deepned than deſtroyed, I collect that the ſalts, which conſtitute theſe ſpirits, are rather ſulphureous than acid. And to ſatisfy my ſelf yet farther in this particular, I take a ſmall phial of freſh tincture, and placing both it and my ſelf in reference to the light as formerly, I drop into the infuſion juſt as much diſtilled vinegar, or other acid liquor as will ſerve to deprive it of its blueneſs, (which a few drops, if the ſour liquor be ſtrong, and phial ſmall, will ſuffice to do ;) then without changing my poſture, I drop and ſhake into the ſame phial a ſmall proportion of ſpirit of hartſhorn or urine, and finding that upon this affuſion the tincture immediately recovers its ceruleous colour, I am thereby confirmed in my former opinion, of the ſulphureous nature of theſe ſalts. And ſo, whereas it is much doubted by ſome modern chymiſts to what ſort of ſalt, that which is predominant in quick-lime belongs, we have been perſuaded to refer it rather to lixiviate than acid ſalts; by having obſerved, that though an evaporated infuſion of it will ſcarce yield ſuch a ſalt, as aſhes and other alcalizate bodies are wont to do, yet if we deprive our nephritick tincture of its blueneſs by juſt ſo much diſtilled vinegar as is requiſite to make that colour vaniſh, the lixivium of quick-lime will immediately upon its affuſion recall the baniſhed colour, but not ſo powerfully as either of the ſulphureous liquors formerly mentioned. And therefore I allow my ſelf to gueſs at the ſtrength of the liquors examined by this experiment, by the quantity of them which is ſufficient to deſtroy or reſtore the ceruleous colour of our tincture. But whether concerning liquors, wherein neither acid nor alcalizate ſalts are eminently predominant, our tincture will enable us to conjecture any thing more than that ſuch ſalts are not predominant in them, I take not upon me to determine here, but leave to further trial; for I find not that ſpirit of wine, ſpirit of tartar freed from acidity, or chymical oil of turpentine, (although liquors which muſt be conceived very ſaline, if chymiſts have, which is here no place to diſpute, rightly aſcribed taſtes to the ſaline principle of bodies,) have any remarkable power either to deprive our tincture of its ceruleous colour, or reſtore it, when upon the affuſion of ſpirit of vinegar it has diſappeared.

EXPERIMENT XI.

AND here I muſt not omit, *Pyrophilus*, to inform you, that we can ſhew you even in a mineral body ſomething that may ſeem very near of kin to the changeable quality of the tincture of *Lignum Nephriticum*; for we have ſeveral flat pieces of glaſs, of the thickneſs of ordinary panes for windows, one of which being interpoſed betwixt the eye and a clear light, appears of a golden colour, not much unlike that of the moderate tincture of our wood; but being ſo looked upon as that the beams of light are not ſo much trajected through it as reflected from it to the eye, that yellow ſeems to degenerate into a pale blue, ſomewhat like that of a turquoiſe. And that which may alſo appear ſtrange, is this, that if in a certain poſture you hold one of theſe plates perpendicular to the horizon, ſo that the ſun-beams ſhine upon half of it, the other half being ſhaded, you may ſee that the part ſhined upon will be of a much diluter yellow than the ſhaded part, which will appear more richly coloured; and if you alter the poſture of the glaſs, ſo that it be not held perpendicular, but parallel in reference to the horizon, you may ſee, (which perhaps you will admire) the ſhaded part look of a golden colour, but the other that the ſun ſhines freely on, will appear conſiderably blue, and as you remove any part of the glaſs thus held horizontally into the ſun-beams or ſhade, it will in the twinkling of an eye ſeem to paſs from one of the above mentioned colours to the other; the ſun-beams trajected through it upon a ſheet of white-paper held near it, do colour it with yellow, ſomewhat bordering upon a red, but yet the glaſs may be ſo oppoſed to the ſun, that it may upon paper project a mixed colour here and there more inclined to yellow, and here and there more to blue. The other phænomena of this odd glaſs, I fear it would be ſcarce worth while to record; and therefore I ſhall rather advertiſe you, firſt, that in the trying of theſe experiments with it, you muſt take notice that one of the ſides has either alone, or at leaſt principally, its ſuperficial parts diſpoſed to the reflection of the blue colour above named, and that therefore you muſt have a care to keep that ſide neareſt to the eye. And next, that we have our ſelves made glaſſes not unfit to exhibit an experiment not unlike that I have been ſpeaking of, by laying upon pieces of glaſs ſome very finely foliated ſilver, and giving it by degrees a much ſtronger fire than is requiſite or uſual for the tinging of glaſſes of other colours. And this experiment, not to mention that it was made without a furnace, in which artificers that paint glaſs are wont to be very curious, is the more conſiderable, becauſe, that though a ſkilful painter could not deny to me that it was with ſilver he coloured his glaſſes yellow; yet he told me, that when to burn them (as they ſpeak) he lays on the plates of glaſs, nothing but a calx of ſilver calcined without corroſive liquors, and tempered with fair water, the plates are tinged of a fine yellow that looks of a golden colour, which part ſoever of it you turn to or from the light; whereas (whether it be what an artificer would call over-doing, or burning, or elſe the imploying the ſilver crude that makes the difference) we have found more than once, that ſome pieces of glaſs prepared as we have related,

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lated, though held againſt the light they appeared of a tranſparent yellow, yet looked on with one's back turned to the light, they exhibited an untranſparent blue.

EXPERIMENT XII.

IF you will allow me, *Pyrophilus*, for the avoiding of ambiguity, to imploy the word pigments, to ſignify ſuch prepared materials (as cochineal, vermilion, orpiment,) as painters, dyers, and other artificers make uſe of to impart or imitate particular colours; I ſhall be the better underſtood in divers paſſages of the following papers, and particularly when I tell you, that the mixing of pigments being no inconſiderable part of the painters art, it may ſeem an incroachment in me to meddle with it. But I think I may eaſily be excuſed (though I do not altogether paſs it by) if I reſtrain my ſelf to the making of a tranſient mention of ſome few of their practices about this matter; and that only ſo far forth, as may warrant me to obſerve to you, that there are but few ſimple and primary colours (if I may ſo call them) from whoſe various compoſitions all the reſt do as it were reſult. For though painters can imitate the hues (though not always the ſplendor) of thoſe almoſt numberleſs differing colours that are to be met with in the works of nature, and of art, I have not yet found, that to exhibit this ſtrange variety they need imploy any more than white, and black, and red, and blue, and yellow; theſe five, variouſly compounded, and (if I may ſo ſpeak) decompounded, being ſufficient to exhibit a variety and number of colours, ſuch, as thoſe that are altogether ſtrangers to the painters pallets, can hardly imagine.

THUS (for inſtance) black and white differingly mixed, make a vaſt company of lighter and darker greys.

BLUE and yellow make a huge variety of greens.

RED and yellow make orange tawny.

RED with a little white makes a carnation.

RED with an eye of blue, makes a purple; and by theſe ſimple compoſitions again compounded among themſelves, the ſkilful painter can produce what kind of colour he pleaſes, and a great many more than we have yet names for. But, as I intimated above, it is not my deſign to proſecute this ſubject, though I thought it not unfit to take ſome notice of it, becauſe we may hereafter have occaſion to make uſe of what has been now delivered, to illuſtrate the generation of intermediate colours; concerning which we muſt yet ſubjoin this caution, that to make the rules about the emergency of colours fit to be relied upon, the corpuſcles whereof the pigments conſiſt muſt be ſuch as do not deſtroy one another's texture; for in caſe they do, the produced colour may be very different from that which would reſult from the mixture of other harmleſs pigments of the ſame colours, as I ſhall have occaſion to ſhew ere long.

EXPERIMENT XIII.

IT may alſo give much light to an inquirer into the nature of colours, to know that not only in green, but in many (if not all) other colours, the light of the ſun paſſing through diaphanous bodies of differing hues may be tinged of the ſame compound colour, as if it came from ſome painters colours of the ſame denomination, though this later be exhibited by reflection, and be (as the former experiment declares) manifeſtly compounded of material pigments. Wherefore to try the compoſition of colours by trajection, we provided ſeveral plates of tinged glaſs, which being laid two at a time, one on the top of another, the object looked upon through them both, appeared of a compounded colour, which agrees well with what we have obſerved in the ſecond experiment, of looking againſt the light through differingly coloured papers. But we thought the experiment would be more ſatisfactory, if we procured the ſun-beams to be ſo tinged in their paſſage through plates of glaſs, as to exhibit the compounded colour upon a ſheet of white paper. And though by reaſon of the thickneſs of the glaſſes, the effect was but faint, even when the ſun was high and ſhined forth clear, yet, we eaſily remedied that by contracting the beams we caſt on them by means of a convex burning-glaſs, which, where it made the beams much converge, increaſed the light enough to make the compounded colour very manifeſt upon the paper. By this means we obſerved, that the beams trajected through blue and yellow compoſed a green; that an intenſe and moderate red did with yellow make differing degrees of ſaffron, and orange-tawny colours; that green and blue made a colour partaking of both, ſuch as that which ſome Latin writers call *Pavonaceus*; that red and blue made a purple; to which we might add other colours, that we produced by the combinations of glaſſes differingly tinged, but that I want proper words to expreſs them in our language, and had not, when we made the trials, the opportunity of conſulting with a painter, who perchance might have ſupplied me with ſome of the terms I wanted.

I KNOW not whether it will be requiſite to ſubjoin on this occaſion, what I tried concerning reflections from coloured glaſſes, and other tranſparent bodies; namely, that having expoſed four or five ſorts of them to the ſun, and caſt the reflected beams upon white paper held near at hand, the light appeared not manifeſtly tinged, but as if it had been reflected from the impervious parts of a colourleſs glaſs; only that reflected from the yellow was here and there ſtained with the ſame colour, as if thoſe beams were not all reflected from the ſuperficial, but ſome from the internal parts of the glaſs; upon which occaſion you may take notice, that a ſkilful tradeſman, who makes ſuch coloured glaſs, told me, that whereas the red pigment was but ſuperficial, the yellow penetrated to the very midſt of the plate. But for further ſatisfaction, not having the opportunity to

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to foliate thoſe plates, and ſo turn them into looking-glaſſes, we foliated a plate of *Muſcovy* glaſs, and then laying on it a little tranſparent varniſh of a gold colour, we expoſed it to the ſun-beams, ſo as to caſt them upon a body fit to receive them; on which the reflected light appearing, as we expected, yellow, manifeſted that rebounding from the ſpecular part of the ſelenitis, it was tinged in its return with the colour of the tranſparent varniſh through which it paſſed.

EXPERIMENT XIV.

AFTER what we have ſaid of the compoſition of colours, it will now be ſeaſonable to annex ſome experiments that we made in favour of thoſe colours, that are taught in the ſchools not to be real, but only apparent and fantaſtical; for we found by trials, that theſe colours might be compounded, both with true and ſtable colours, and with one another, as well as unqueſtionably genuine and laſting colours, and that the colours reſulting from ſuch compoſitions, would reſpectively deſerve the ſame denominations.

FOR firſt, having by the trajection of the ſun-beams through a glaſs priſm thrown an iris on the floor, I found that by placing a blue glaſs at a convenient diſtance betwixt the priſm and the iris, that part of the iris that was before yellow, might be made to appear green, though not of a graſs green, but of one more dilute and yellowiſh. And it ſeems not improbable, that the narrow greeniſh liſt (if I may ſo call it) that is wont to be ſeen between the yellow and blue parts of the iris, is made by the confuſion of thoſe two bordering colours.

NEXT, I found, that though the want of a ſufficient livelineſs in either of the compounding colours, or a light error in the manner of making the following trials, was enough to render ſome of them unſucceſsful, yet, when all neceſſary circumſtances were duly obſerved, the event was anſwerable to our expectation and deſire.

AND (as I formerly noted) that red and blue compound a purple, ſo I could produce this laſt named colour, by caſting at ſome diſtance from the glaſs the blue part of the priſmatical iris (as I think it may be called for diſtinction ſake) upon a lively red, (or elſe the experiment ſucceeds not ſo well.) And I remember, that ſometimes when I tried this upon a piece of red cloth, that part of the iris which would have been blue, (as I tried by covering that part of the cloth with a piece of white paper) and compounded with the red, wherewith the cloth was imbued before, appeared of a fair purple, did, when I came to view it near at hand, look very oddly, as if there were ſome ſtrange reflection or refraction, or both, made in the hairs of which that cloth was compoſed.

CASTING likewiſe the priſmatical iris upon a very vivid blue, I found that part of it, which would elſe have been the yellow, appear green. (Another ſomewhat differing trial, and yet fit to confirm this, you will find in the fifteenth experiment.)

BUT it may ſeem ſomewhat more ſtrange, that though the priſmatical iris being made by the refraction of light through a body that has no colour at all, muſt, according to the doctrine of the ſchools, conſiſt of as purely emphatical colours as may be, yet even theſe may be compounded with one another, as well as real colours in the groſſeſt pigments. For I took at once two triangular glaſſes, and one of them being kept fixt in the ſame poſture, that the iris it projected on the floor might not waver, I caſt on the ſame floor another iris with the other priſm, and moving it to and fro to bring what part of the ſecond iris I pleaſed, to fall upon what part of the firſt I thought fit, we did ſometimes (for a ſmall error ſuffices to hinder the ſucceſs) obtain by this means a green colour in that part of the more ſtable iris, that before was yellow, or blue; and frequently by caſting thoſe beams, that in one of the iris's made the blue upon the red parts of the other iris, we were able to produce a lovely purple, which we can deſtroy or recompoſe at pleaſure, by ſevering and re-approaching the edges of the two iris's.

EXPERIMENT XV.

ON this occaſion, *Pyrophilus*, I ſhall add, that finding the glaſs priſm to be the uſefulleſt inſtrument men have yet employed about the contemplation of colours, and conſidering that priſms, hitherto in uſe, are made of glaſs tranſparent and colourleſs, I thought it would not be amiſs to try, what change the ſuperinduction of a colour, without the deſtruction of the diaphaneity, would produce in the colours exhibited by the priſm. But being unable to procure one to be made of coloured glaſs, and fearing alſo that if it were not carefully made, the thickneſs of it would render it too opacous, I endeavoured to ſubſtitute one made of clarified roſin, or of turpentine brought (as I elſewhere teach) to the conſiſtence of a tranſparent gum. But though theſe endeavours were not wholly loſt, yet we found it ſo difficult to give theſe materials their true ſhape, that we choſe rather to varniſh over an ordinary priſm with ſome of thoſe few pigments that are to be had tranſparent; as accordingly we did firſt with yellow, and then with red, or rather crimſon, made with lake tempered with a convenient oil; and the event was, that for want of good tranſparent colours (of which you know there are but very few) both the yellow and the red made the glaſs ſo opacous, (though the pigment were laid on but upon two ſides of the glaſs, no more being abſolutely neceſſary) that unleſs I looked upon an enlightened window, or the flame of a candle, or ſome other luminous or very vivid object, I could ſcarce diſcern any colours at all, eſpecially when the glaſs was covered with red. But when I did look on ſuch objects, it appeared (as I expected) that the colour of the pigment had vitiated or drowned ſome of thoſe which the priſm would, according to its wont, have exhi-

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bited, and mingling with others, altered them: as I remember, that both to my eyes, and others to whom I ſhewed it, when the priſm was covered with yellow, it made thoſe parts of bright objects, where the blue would elſe have been conſpicuous, appear of a light green. But, *Pyrophilus*, both the nature of the colours, and the degree of tranſparency, or of darkneſs in the pigment, beſides divers other circumſtances, did ſo vary the phænomena of theſe trials, that till I can procure ſmall coloured priſms, or hollow ones that may be filled with tincted liquor, or obtain ſome better pigments than thoſe I was reduced to employ, I ſhall forbear to build any thing upon what has been delivered, and ſhall make no other uſe of it, than to invite you to proſecute the inquiry further.

EXPERIMENT XVI.

AND here, *Pyrophilus*, ſince we are treating of emphatical colours, we ſhall add what we think not unworthy your obſervation, and not unfit to afford ſome exerciſe to the ſpeculative. For there are ſome liquors which, though colourleſs themſelves, when they come to be elevated, and diſperſed into exhalations, exhibit a conſpicuous colour, which they loſe again, when they come to be reconjoined into a liquor; as good ſpirit of nitre, or upon its account ſtrong aqua fortis, though devoid of all appearance of redneſs whilſt they continue in the form of a liquor, if a little heat chance to turn the minute parts of them into vapours, the ſteam will appear of a reddiſh or deep yellow colour, which will vaniſh when thoſe exhalations come to reſume the form of a liquor.

AND not only if you look upon a glaſs half full of aqua fortis, or ſpirit of nitre, and half full of nitrous ſteams proceeding from it, you will ſee the upper part of the glaſs of the colour freſhly mentioned, if through it you look upon the light. But which is much more conſiderable, I have tried, that putting aqua fortis in a long clear glaſs, and adding a little copper or ſome ſuch open metal to it, to excite heat and fumes, the light trajected through thoſe fumes, and caſt upon a ſheet of white paper, did upon that appear of the colour that the fumes did, when directly looked upon, as if the light were as well tinged in its paſſage through theſe fumes, as it would have been by paſſing through ſome glaſs or liquor in which the ſame colour was inherent.

To which I ſhall further add, that having ſometimes had the curioſity to obſerve whether the beams of the ſun near the horizon, trajected through a very red ſky, would not (though ſuch redneſſes are taken to be but emphatical colours) exhibit the like colour; I found that the beams falling within a room upon a very white object, placed directly oppoſite to the ſun, diſcloſed a manifeſt redneſs, as if they had paſſed through a coloured medium.

EXPERIMENT XVII.

THE emergency, *Pyrophilus*, of colours upon the coalition of the particles of ſuch bodies as were neither of them of the colour of that mixture whereof they are the ingredients, is very well worth our attentive obſervation, as being of good uſe both ſpeculative and practical: for much of the mechanical uſe of colours among painters and dyers doth depend upon the knowledge of what colours may be produced by the mixtures of pigments ſo and ſo coloured. And (as we lately intimated) it is of advantage to the contemplative Naturaliſt, to know how many and which colours are primitive (if I may ſo call them) and ſimple, becauſe it both eaſes his labour by confining his moſt ſollicitous inquiry to a ſmall number of colours upon which the reſt depend, and aſſiſts him to judge of the nature of particular compounded colours, by ſhewing him, from the mixture of what more ſimple ones, and of what proportions of them to one another, the particular colour to be conſidered does reſult. But becauſe, to inſiſt on the proportions, the manner and the effects of ſuch mixtures, would oblige me to conſider a greater part of the painter's art and dyer's trade, than I am well acquainted with, I confined my ſelf to make trial of ſeveral ways to produce green, by the compoſition of blue and yellow: and ſhall in this place both recapitulate moſt of the things I have diſperſedly delivered already concerning that ſubject, and recruit them.

AND firſt, whereas painters (as I noted above) are wont to make green by tempering blue and yellow, both of them made into a ſoft conſiſtence, with either water or oil, or ſome liquor of kin to one of thoſe two, according as the picture is to be drawn with thoſe they call water-colours, or thoſe they term oil-colours; I found, that by chuſing fit ingredients, and mixing them in the form of dry powders, I could do, what I could not if the ingredients were tempered up with a liquor: but the blue and yellow powders muſt not only be finely ground, but ſuch as that the corpuſcles of the one may not be too unequal to thoſe of the other, leſt by their diſproportionate minuteneſs the ſmaller cover and hide the greater. We uſed with good ſucceſs a ſlight mixture of the fine powder of biſe, with that of orpiment, or that of good yellow oker; I ſay, a ſlight mixture, becauſe we found that an exquiſite mixture did not do ſo well: but by lightly mingling the two pigments in ſeveral little parcels, thoſe of them in which the proportion and manner of mixture was more lucky, afforded us a good green.

2. WE alſo learned in the dye-houſes, that cloth being dyed blue with woad, is afterwards by the yellow decoction of woud-wax or wood-wax dyed into a green colour.

3. YOU may alſo remember what we above related, where we intimated, that having in a darkened room taken two bodies, a blue and a yellow, and caſt the light reflected from the one upon the other, we likewiſe obtained a green.

4. AND you may remember, that we obſerved a green to be produced, when in the ſame darkned room we looked at the hole at which alone the light entered, through the green and yellow parts of a ſheet of marbled paper laid over one another.

5. WE

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5. We found too, that the beams of the ſun being trajected through two pieces of glaſs, the one blue and the other yellow, laid over one another, did upon a ſheet of white paper, on which they were made to fall, exhibit a lovely green.

6. I Hope alſo, that you have not already forgot, what was ſo lately delivered, concerning the compoſition of a green, with a blue and yellow; of which moſt authors would call the one a real, and the other an emphatical.

7. And I preſume, you may have yet freſh in your memory, what the fourteenth experiment informs you, concerning the exhibiting of a green, by the help of a blue and yellow, that were both of them emphatical.

8. Wherefore we will proceed to take notice, that we alſo deviſed a way of trying whether or no metalline ſolutions, though one of them at leaſt had its colour adventitious, by the mixture of the menſtruum employed to diſſolve it, might not be made to compound a green after the manner of other bodies. And though this ſeemed not eaſy to be performed by reaſon of the difficulty of finding metalline ſolutions of the colour requiſite, that would mix without precipitating each other; yet after a while having conſidered the matter, the firſt trial afforded me the following experiment. I took a high yellow ſolution of good gold in aqua regis, (made of aqua-fortis, and as I remember half its weight of ſpirit of ſalt;) to this I put a due proportion of a deep and lovely blue ſolution of crude copper, (which I have elſewhere taught to be readily diſſolvable in ſtrong ſpirit of urine.) And theſe two liquors, though at firſt they ſeemed a little to curdle one another, yet being thoroughly mingled by ſhaking, they preſently, as had been conjectured, united into a tranſparent green liquor, which continued ſo for divers days, that I kept it in a ſmall glaſs wherein it was made, only letting fall a little blackiſh powder to the bottom. The other phænomena of this experiment belong not to this place, where it may ſuffice to take notice of the production of a green, and that the experiment was more than once repeated with ſucceſs.

9. And laſtly, to try whether this way of compounding colours would hold even in ingredients actually melted by the violence of the fire, provided their texture were capable of ſafely enduring fuſion, we cauſed ſome blue and yellow ammel to be long and well wrought together in the flame of a lamp, which being ſtrongly and inceſſantly blown on them, kept them in ſome degree of fuſion, and at length (for the experiment requires ſome patience as well as ſkill) we obtained the expected ammel of a green colour.

I Know not, *Pyrophilus*, whether it be worth while to acquaint you with the ways that came into my thoughts, whereby in ſome meaſure to explicate the firſt of the mentioned ways of making a green; for I have ſometimes conjectured, that the mixture of the biſe and the orpiment produced a green by ſo altering the ſuperficial aſperity, which each of thoſe ingredients had apart, that the light incident on the mixture was reflected with differing ſhades, as to quantity, or order, or both, from thoſe of either of the ingredients, and ſuch as the light is wont to be modified with, when it reflects from graſs, or leaves, or ſome of thoſe other bodies that we are wont to call green. And ſometimes too I have doubted, whether the produced green might not be partly at leaſt derived from this, that the beams that rebound from the corpuſcles of the orpiment, giving one kind of ſtroke upon the retina, whoſe perception we call yellow, and the beams reflected from the corpuſcles of the biſe giving another ſtroke upon the ſame retina, like to objects that are blue; the contiguity and minuteneſs of theſe corpuſcles may make the appulſe of the reflected light fall upon the retina within ſo narrow a compaſs, that the part they beat upon being as it were a phyſical point, they may give a compounded ſtroke, which may conſequently exhibit a compounded and new kind of ſenſation: as we ſee that two ſtrings of a muſical inſtrument being ſtruck together, making two noiſes that arrive at the ear at the ſame time as to ſenſe, yield a ſound differing from either of them, and as it were compounded of both; inſomuch that if they be diſcordantly tuned, though each of them ſtruck apart would yield a pleaſing ſound, yet being ſtruck together they make but a harſh and troubleſome noiſe. But this not being ſo fit a place to proſecute ſpeculations, I ſhall not inſiſt, neither upon theſe conjectures nor any others, which the experiment we have been mentioning may have ſuggeſted to me. And I ſhall leave it to you, *Pyrophilus*, to derive what inſtruction you can from comparing together the various ways whereby a yellow and a blue can be made to compound a green: that which I now pretend to, being only to ſhew that the firſt of thoſe mentioned ways, (not to take at preſent notice of the reſt) does far better agree with our conjectures about colours, than either with the doctrine of the ſchools, or with that of the chymiſts, both which ſeem to be very much diſfavoured by it.

For firſt, ſince in the mixture of the two mentioned powders I could by the help of a very excellent microſcope (for ordinary ones will ſcarce ſerve the turn) diſcover that which ſeemed to the naked eye a green body, to be but a heap of diſtinct, though very ſmall grains of yellow orpiment and blue biſe confuſedly enough blended together, it appears that the coloured corpuſcles of either kind did each retain its own nature and colour; by which it may be gueſſed, what meer tranſpoſition and juxtapoſition of minute and ſingly unchanged particles of matter can do to produce a new colour. For that this local motion and new diſpoſition of the ſmall parts of the orpiment did intervene, is much more manifeſt than it is eaſy to explicate how they ſhould produce this new green, otherwiſe than by the new manner of their being put together, and conſequently

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conſequently by their new diſpoſition to modify the incident light, by reflecting it otherwiſe than they did before they were mingled together.

SECONDLY, The green thus made, being (if I may ſo ſpeak) mechanically produced, there is no pretence to derive it from I know not what incomprehenſible ſubſtantial form, from which yet many would have us believe that colours muſt flow; nor does this green, though a real and permanent, not a phantaſtical and vanid colour, ſeem to be ſuch an inherent quality as they would have it, ſince not only each part of the mixture remains unaltered in colour, and conſequently of a differing colour from the heap they compoſe; but if the eye be aſſiſted by a microſcope to diſcern things better and more diſtinctly than before it could, it ſees not a green body, but a heap of blue and yellow corpuſcles.

AND in the third place, I demand what either ſulphur, or ſalt, or mercury has to do in the production of this green; for neither the biſe nor the orpiment were indued with that colour before; and the bare juxtapoſition of the corpuſcles of the two powders that work not upon each other, but might, if we had convenient inſtruments, be ſeparated, unaltered, cannot, with any probability, be imagined either to increaſe or diminiſh any of the three hypoſtatical principles, (to which of them ſoever the chymiſts are pleaſed to aſcribe colours;) nor does there here intervene ſo much as heat to afford them any colour to pretend, that at leaſt there is made an extraverſion (as the Helmontians ſpeak) of the ſulphur, or of any of the two other ſuppoſed principles. But upon this experiment we have already reflected enough, if not more than enough for once.

EXPERIMENT XVIII.

BUT here, *Pyrophilus*, I muſt advertiſe you, that 'tis not every yellow and every blue that, being mingled, will afford a green; for in caſe one of the ingredients do not act only as endowed with ſuch a colour, but as having a power to alter the texture of the corpuſcles of the other, ſo as to indiſpoſe them to reflect the light, as corpuſcles that exhibit a blue or a yellow are wont to reflect it; the emergent colour may be not green, but ſuch as the change of texture in the corpuſcles of one or both of the ingredients qualifies them to ſhew forth: as for inſtance, if you let fall a few drops of ſyrup of violets upon a piece of white paper, though the ſyrup being ſpread will appear blue, yet mingling with it two or three drops of the lately mentioned ſolution of gold, I obtained not a green but a reddiſh mixture, which I expected from the remaining power of the acid ſalts abounding in the ſolution, ſuch ſalts or ſaline ſpirits being wont, as we ſhall ſee anon, though weakened, ſo to work upon that ſyrup as to change it into a red or reddiſh colour. And to confirm that for which I alledge the former experiment, I ſhall add this other, that having made a very ſtrong and high-coloured ſolution of filings of copper with ſpirit of urine, though the menſtruum ſeemed glutted with the metal, becauſe I put in ſo much filings, that many of them remained for divers days undiſſolved at the bottom; yet having put three or four drops of ſyrup of violets upon white paper, I found that the deep blue ſolution proportionably mingled with this other blue liquor, did not make a blue mixture, but, as I expected, a fair green, upon the account of the urinous ſalt that was in the menſtruum.

EXPERIMENT XIX.

TO ſhew the chymiſts, that colours may be made to appear or vaniſh, where there intervenes no acceſſion or change either of the ſulphureous, or the ſaline, or the mercurial principle (as they ſpeak) of bodies; I ſhall not make uſe of the iris afforded by the glaſs-priſm, nor of the colours to be ſeen in a fair morning in thoſe drops of dew that do in a convenient manner reflect and refract the beams of light to the eye: but I will rather mind them of what they may obſerve in their own laboratories, namely, that divers, if not all, chymical eſſential oils, as alſo good ſpirit of wine, being ſhaken till they have good ſtore of bubbles, thoſe bubbles will (if attentively conſidered) appear adorned with various and lovely colours, which all immediately vaniſh, upon the relapſing of the liquor that affords thoſe bubbles their ſkins, into the reſt of the oil, or ſpirit of wine; ſo that a colourleſs liquor may be made in a trice to exhibit variety of colours, and may loſe them in a moment without the acceſſion or diminution of any of its hypoſtatical principles. And, by the way, 'tis not unworthy our notice, that ſome bodies, as well colourleſs as coloured, by being brought to a great thinneſs of parts, acquire colours though they had none before, or colours differing from them they were before endued with: For, not to inſiſt on the variety of colours, that water, made ſomewhat glutinous by ſoap, acquires when 'tis blown into ſuch ſpherical bubbles as boys are wont to make and play with; turpentine (though it have a colour deep enough of its own) may (by being blown into after a certain manner) be brought to afford bubbles adorned with variety of orient colours, which though they vaniſh ſome while upon the breaking of the bubbles, yet they would in all likelihood always exhibit colours upon their ſuperficies, (though not always the ſame in the ſame parts of them, but varied according to the incidence of the ſight, and the poſition of the eye) if their texture were durable enough. For I have ſeen one that was ſkilled at faſhioning glaſſes by the help of a lamp, blowing ſome of them ſo ſtrongly as to burſt them; whereupon it was found, that the tenacity of the metal was ſuch, that before it broke, it ſuffered itſelf to be reduced into films ſo extremely thin, that being kept clean they conſtantly ſhewed on their ſurfaces (but after the manner newly mentioned) the varying colours of the rain-bow, which were exceedingly vivid, as I had often opportunity to obſerve in ſome, that I cauſed purpoſely to be made, to keep by me.

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But leſt it ſhould be objected, that the above-mentioned inſtances are drawn from tranſparent liquors, it may poſſibly appear not impertinent to add, what I have ſometimes thought upon, and ſeveral times tried, when I was conſidering the opinions of the chymiſts about colours. I took then a feather of a convenient bigneſs and ſhape, and holding it at a fit diſtance betwixt my eye and the ſun when he was near the horizon, methought there appeared to me a variety of little rainbows, with differing and very vivid colours, of which none was conſtantly to be ſeen in the feather; the like phænomenon I have at other times (though not with altogether ſo good ſucceſs) produced, by interpoſing at a due diſtance a piece of black ribband betwixt the almoſt ſetting ſun and my eye; not to mention the trials I have made to the ſame purpoſe, with other bodies.

EXPERIMENT XX.

TAKE good ſyrup of violets, impregnated with the tincture of the flowers, drop a little of it upon a white paper, (for by that means the change of colour will be more conſpicuous, and the experiment may be practiſed in ſmaller quantities) and on this liquor let fall two or three drops of ſpirit either of ſalt or vinegar, or almoſt any other eminently acid liquor, and upon the mixture of theſe you ſhall find the ſyrup immediately turned red: and the way of effecting ſuch a change has not been unknown to divers perſons, who have produced the like, by ſpirit of vitriol, or juice of lemons, but have groundleſly aſcribed the effect to ſome peculiar quality of thoſe two liquors, whereas (as we have already intimated) almoſt any acid ſalt will turn ſyrup of violets red. But to improve the experiment, let me add what has not (that I know of) been hitherto obſerved, and has, when we firſt ſhewed it them, appeared ſomething ſtrange, even to thoſe that have been inquiſitive into the nature of colours; namely, that if inſtead of ſpirit of ſalt, or that of vinegar, you drop upon the ſyrup of violets a little oil of tartar *per deliquium*, or the like quantity of ſolution of pot-aſhes, and rub them together with your finger, you ſhall find the blue colour of the ſyrup turned in a moment into a perfect green; and the like may be performed by divers other liquors, as we may have occaſion elſewhere to inform you.

Annotation upon the Twentieth EXPERIMENT.

THE uſe of what we lately delivered concerning the way of turning ſyrup of violets red or green, may be this; that, though it be a far more common and procurable liquor than the infuſion of *lignum nephriticum*, it may yet be eaſily ſubſtituted in its room, when we have a mind to examine, whether or no the ſalt predominant in a liquor or other body, wherein it is looſe and abundant, belong to the tribe of acid ſalts or not. For if ſuch a body turn the ſyrup of a red or reddiſh purple colour, it does for the moſt part argue the body (eſpecially if it be a diſtilled liquor) to abound with acid ſalt. But if the ſyrup be made green, that argues the predominant ſalt to be of a nature repugnant to that of the tribe of acids. For, as I find that either ſpirit of ſalt, or oil of vitriol, or aqua-fortis, or ſpirit of vinegar, or juice of lemons, or any of the acid liquors I have yet had occaſion to try, will turn ſyrup of violets of a red, or at leaſt of a reddiſh colour; ſo I have found, that not only the volatile ſalts of all animal ſubſtances I have uſed, as ſpirit of hartſhorn, of urine, of ſal-armoniack, of blood, *&c.* but alſo all the alcalizate ſalts I have employed, as the ſolution of ſalt of tartar, of pot-aſhes, of common wood-aſhes, lime-water, *&c.* will immediately change the blue ſyrup into a perfect green. And by the ſame way (to hint that upon the by) I elſewhere ſhow you, both the changes that nature and time produce, in the more ſaline parts of ſome bodies, may be diſcovered, and alſo how even ſuch chymically prepared bodies, as belong not either to the animal kingdom, or to the tribe of alcalies, may have their new and ſuperinduced nature ſucceſsfully examined. In this place I ſhall only add, that not alone the changing the colour of the ſyrup requires, that the changing body be more ſtrong of the acid, or other ſort of ſalt, that is predominant in it, than is requiſite for the working upon the tincture of *lignum nephriticum*; but that in this alſo, the operation of the formerly mentioned ſalts upon our ſyrup, differs from their operation upon our tinctures; that in this liquor, if the ceruleous colour be deſtroyed by an acid ſalt, it may be reſtored by one that is either volatile, or lixiviate; whereas in ſyrup of violets, though one of theſe contrary ſalts will deſtroy the action of the other, yet neither of them will reſtore the ſyrup to its native blue; but each of them will change it into the colour which itſelf doth (if I may ſo ſpeak) affect, as we ſhall have occaſion to ſhew in the notes on the twenty-fifth experiment.

EXPERIMENT XXI.

THERE is a weed, more known to plowmen than beloved by them, whoſe flowers from their colour are commonly called blue-bottles, and corn-weed from their growing among corn. Theſe flowers, ſome ladies do, upon the account of their lovely colour, think worth the being candied, which when they are, they will long retain ſo fair a colour, as makes them a very fine ſallad in the winter. But I have tried, that when they are freſhly gathered, they will afford a juice, which when newly expreſſed, (for in ſome caſes it will ſoon enough degenerate) affords a very deep and pleaſant blue. Now, (to draw this to our preſent ſcope) by dropping on this freſh juice a little ſpirit of ſalt, (that being the acid ſpirit I had then at hand) it immediately turned (as I predicted) into a red. And if inſtead of the ſour ſpirit, I mingled with it a little ſtrong ſolution of an alcalizate ſalt, it did preſently diſcloſe a lovely green; the ſame changes being, by thoſe differing ſorts of ſaline liquors, producible in this natural juice, that we lately mentioned to have

Herbariſts *are wont to call this plant* Cyanus vulgaris minor.

have happened to that factitious mixture, the ſyrup of violets. And I remember, that finding this blue liquor, when freſhly made, to be capable of ſerving in a pen for an ink of that colour, I attempted by moiſtening one part of a piece of white paper with the ſpirit of ſalt I have been mentioning, and another with ſome alcalizate or volatile liquor, to draw a line on the leiſurely dryed paper, that ſhould even before the ink was dry appear partly blue, partly red, and partly green: but though the latter part of the experiment ſucceeded not well, (whether becauſe volatile ſalts are too fugitive to be retained in the paper, and alcalizate ones are too unctuous, or ſo apt to draw moiſture from the air, that they keep the paper from drying well) yet the former part ſucceeded well enough; the blue and the red being conſpicuous enough to afford a ſurprizing ſpectacle to thoſe, I acquaint not with (what I willingly allow you to call) the trick.

Annotation upon the one and twentieth EXPERIMENT.

BUT leſt you ſhould be tempted to think *(Pyrophilus)* that volatile or alcalizate ſalts change blues into green, rather upon the ſcore of the eaſy tranſition of the former colour into the latter, than upon the account of the texture, wherein moſt vegetables, that afford a blue, ſeem, though otherwiſe differing, to be allied; I will add, that when I purpoſely diſſolved blue vitriol in fair water, and thereby imbued ſufficiently that liquor with that colour, a lixiviate liquor, and a urinous ſalt being copiouſly poured upon diſtinct parcels of it, did each of them, though perhaps with ſome difference, turn the liquor not green, but of a deep yellowiſh colour, almoſt like that of yellow oker; which colour, the precipitated corpuſcles retained, when they had leiſurely ſubſided in the bottom. What this precipitated ſubſtance is, it is not needful now to inquire in this place, and in another I have ſhewn you, that notwithſtanding its colour, and its being obtainable from an acid menſtruum by the help of ſalt of tartar, it is yet far enough from being the true ſulphur of vitriol.

EXPERIMENT XXII.

OUR next experiment *(Pyrophilus)* will perhaps ſeem to be of a contrary nature to the two former, made upon ſyrup of violets and juice of blue-bottles. For, as in them, by affuſion of oil of tartar, a blueiſh liquor is made green, ſo in this, by the ſole mixture of the ſame oil, a greeniſh liquor becomes blue. The hint of this experiment was given us by the practice of ſome Italian painters, who being wont to counterfeit *Ultra-marine Azure* (as they call it) by grinding verdigreaſe with ſal-armoniac, and ſome other ſaline ingredients, and letting them rot (as they imagine) for a good while together in a dunghill, we ſuppoſed that the change of colour wrought in the verdigreaſe by this way of preparation muſt proceed from the action of certain volatile and alcalizate ſalts, abounding in ſome of the mingled concretes, and brought to make a further diſſolution of the copper abounding in the verdigreaſe; and therefore we conjectured, that if both the verdigreaſe, and ſuch ſalts were diſſolved in fair water, the ſmall parts of both being therein more ſubdivided and ſet at liberty, would have better acceſs to each other, and thereby incorporate much the more ſuddenly. And accordingly we found, that if upon a ſtrong ſolution of good French verdigreaſe (for it is that we are wont to imploy, as the beſt) you pour a juſt quantity of oil of tartar, and ſhake them well together, you ſhall immediately ſee a notable change of colour, and the mixture will grow thick, and not tranſparent; but if you ſtay a while, till the groſſer part be precipitated to, and ſettled in the bottom, you may obtain a clear liquor of a very lovely colour, and exceeding delightful to the eye. But, you muſt have a care to drop in a competent quantity of oil of tartar, for elſe the colour will not be ſo deep and rich; and if inſtead of this oil you employ a clear lixivium of pot-aſhes, you may have an azure ſomewhat lighter or paler than, and therefore differing from, the former. And if inſtead of either of theſe liquors, you make uſe of ſpirit of urine, or of hartſhorn, you may, according to the quantity and quality of the ſpirit you pour in, obtain ſome further variety (though ſcarce conſiderable) of ceruleous liquors. And yet lately by the help of this urinous ſpirit we made a blue liquor, which not a few ingenious perſons, and among them, ſome, whoſe profeſſion makes them very converſant with colours, have looked upon with ſome wonder. But theſe azure-coloured liquors ſhould be freed from the ſubſiding matter, which the ſalts of tartar or urine precipitate out of them, rather by being decanted, than by filtration. For by the latter of theſe ways, we have ſometimes found the colour of them very much impaired, and little ſuperiour to that of the groſſer ſubſtance, that is left in the filtre.

EXPERIMENT XXIII.

THAT roſes held over the fume of ſulphur, may quickly by it be deprived of their colour, and have as much of their leaves, as the fume works upon, burned pale, is an experiment, that divers others have tried, as well as I. But *(Pyrophilus)* it may ſeem ſomewhat ſtrange to one that has never conſidered the compounded nature of brimſtone, that whereas the fume of ſulphur will, as we have ſaid, whiten the leaves of roſes; that liquor, which is commonly called, oil of ſulphur *per campanam*, becauſe it is ſuppoſed to be made by the condenſation of theſe fumes, in glaſſes ſhaped like bells, into a liquor, does powerfully heighten the tincture of red roſes, and make it more red and vivid, as we have eaſily tried by putting ſome red-roſe leaves, that had been long dried (and ſo had loſt much of their colour) into a phial of fair water. For a while after the affuſion of a convenient quantity

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tity of the liquor we are ſpeaking of, both the leaves themſelves, and the water they were ſteeped in, diſcovered a very freſh and lovely colour.

EXPERIMENT XXIV.

IT may *(Pyrophilus)* ſomewhat ſerve to illuſtrate, not only the doctrine of pigments, and of colours, but divers other parts of the corpuſcular philoſophy, as that explicates odours, and many other things, not as the ſchools by airy qualities, but by real, though extremely minute bodies; to examine, how much of the colourleſs liquor a very ſmall parcel of a pigment may imbue with a diſcernable colour. And though there be ſcarce any thing of preciſeneſs to be expected from ſuch trials, yet I preſumed, that (at leaſt) I ſhould be able to ſhow a much further ſubdiviſion of the parts of matter into viſible particles, than I have hitherto found taken notice of, and than moſt men would imagine; no body, that I know of, having yet attempted to reduce this matter to any meaſure.

THE bodies, the moſt promiſing for ſuch a purpoſe, might ſeem to be the metals, eſpecially gold, becauſe of the multitude and minuteneſs of its parts, which might be argued from the incomparable cloſeneſs of its texture: but though we tried a ſolution of gold made in aqua regia firſt, and then in fair water, yet in regard we were to determine the pigment we employed, not by bulk, but weight, and becauſe alſo, that the yellow colour of gold is but a faint one in compariſon of the deep colour of cochineal, we rather choſe this to make our trials with. But among divers of theſe it will ſuffice to ſet down one, which was carefully made in veſſels conveniently ſhaped, (and that in the preſence of a witneſs, and an aſſiſtant;) the ſum whereof I find among my *Adverſaria*, regiſtered in the following words. To which I ſhall only premiſe, (to leſſen the wonder of ſo ſtrange a diffuſion of the pigment) that cochineal will be better diſſolved, and have its colour far more heightened by ſpirit of urine, than (I ſay not by common water, but) by rectified ſpirit of wine itſelf.

THE note I ſpoke of is this: [One grain of cochineal diſſolved in a pretty quantity of ſpirit of urine, and then diſſolved further by degrees in fair water, imparted a diſcernable, though but a very faint colour, to about ſix glaſs-fulls of water, each of them containing about forty three ounces and a half, which amounts to above a hundred twenty five thouſand times its own weight.]

EXPERIMENT XXV.

IT may afford a conſiderable hint *(Pyrophilus)* to him, that would improve the art of dying, to know what change of colours may be produced by the three ſeveral ſorts of ſalts already often mentioned, (ſome or other of which may be procured in quantity at reaſonable rates) in the juices, decoctions, infuſions, and (in a word) the more ſoluble parts of vegetables. And, though the deſign of this diſcourſe be the improvement of knowledge, not of trades; yet thus much I ſhall not ſcruple to intimate here, that the blue liquors, mentioned in the twentieth, and one and twentieth experiments, are far from being the only vegetable ſubſtances upon which acid, urinous, and alcalizate ſalts have the like operations to thoſe recited in thoſe two experiments. For ripe privet berries (for inſtance) being cruſhed upon white paper, though they ſtain it with a purpliſh colour, yet if we let fall on ſome part of it two or three drops of ſpirit of ſalt, and on the other part a little more of the ſtrong ſolution of pot-aſhes, the former liquor immediately turned that part of the thick juice or pulp, on which it fell, into a lovely red, and the latter turned the other part of it into a delightful green. Though I will not undertake, that thoſe colours in that ſubſtance ſhall not be much more orient than laſting; and though *(Pyrophilus)* this experiment may ſeem to be almoſt the ſame with thoſe already delivered concerning ſyrup of violets, and the juice of blue-bottles, yet I think it not amiſs to take this occaſion to inform you, that this experiment reaches much farther than perhaps you yet imagine, and may be of good uſe to thoſe, whom it concerns to know how dying ſtuffs may be wrought upon by ſaline liquors. For, I have found this experiment to ſucceed in ſo many various berries, flowers, bloſſoms, and other finer parts of vegetables, that neither my memory, nor my leiſure ſerves me to enumerate them. And it is ſomewhat ſurprizing to ſee, by how differingly-coloured flowers, or bloſſoms, (for example) the paper being ſtained, will by an acid ſpirit be immediately turned red, and by any alcaly or any urinous ſpirit turned green; inſomuch that even the cruſhed bloſſoms of meſerion, (which I gathered in winter and froſty weather) and thoſe of peas, cruſhed upon white paper, how remote ſoever their colours be from green, would in a moment paſs into a deep degree of that colour, upon the touch of an alcalizate liquor. To which let us add, that either of thoſe new pigments (if I may ſo call them) may, by the affuſion of enough of a contrary liquor, be preſently changed from red into green, and from green into red: which obſervation will hold alſo in ſyrup of violets, juices of blue-bottles, *&c.*

ANNOTATION.

AFTER what I have formerly delivered to evince that there are many inſtances, wherein new colours are produced or acquired by bodies, which chymiſts are wont to think deſtitute of ſalt, or to whoſe change of colours no new acceſſion of ſaline particles does appear to contribute; I think we may ſafely enough acknowledge, that we have taken notice of ſo many changes made by the intervention of ſalts in the colours of mixed bodies, that it has leſſened our wonder, that though many chymiſts are wont to aſcribe the colours of ſuch bodies to their ſulphureous, and the reſt to their mercurial principle; yet *Paracelſus* himſelf directs us

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in the indagation of colours, to have an eye principally upon ſalts, as we find in that paſſage of his, wherein he takes upon him to oblige his readers much by inſtructing them, of what things they are to expect the knowledge from each of the three diſtinct principles of bodies. *Alias* (ſays he) *colorum ſimilis ratio eſt: de quibus brevem inſtitutionem hanc attendite, quod ſcilicet colores omnes ex ſale prodeant. Sal enim dat colorem, dat balſamum.* And a little beneath; *Jam natura ipſa colores protrahit ex ſale, cuique ſpeciei dans illum, qui ipſi competit, &c.* After which he concludes; *Itaque qui rerum omnium corpora cognoſcere vult, huic opus eſt, ut ante omnia cognoſcat ſulphur; ab hoc, qui deſiderat noviſſe colores, is ſcientiam iſtorum petat à ſale; qui ſcire vult virtutes, is ſcrutetur arcana Mercurii. Sic nimirum fundamentum hauſerit myſteriorum, in quolibet creſcenti indagandorum, prout natura cuilibet ſpeciei ea ingeſſit.* But though *Paracelſus* aſcribes to each of his beloved hypoſtatical principles much more than I fear will be found to belong to it; yet if we pleaſe to conſider colours, not as philoſophers, but as dyers, the concurrence of ſalts to the ſtriking and change of colours, and their efficacy, will, I ſuppoſe, appear ſo conſiderable, that we ſhall not need to quarrel much with *Paracelſus*, for aſcribing in this place (for I dare not affirm that he uſes to be ſtill of one mind) the colours of bodies to their ſalts, if by ſalts he here underſtood not only elementary ſalts, but ſuch alſo as are commonly taken for ſalts, as allom, cryſtals of tartar, vitriol, *&c.* becauſe the ſaline principle does chiefly abound in them, though indeed they be, as we elſewhere declare, mixed bodies, and have moſt of them, beſides what is ſaline, both ſulphureous, aqueous, and groſs or earthy parts.

Paracelſus *de Mineral. tract.* 1. *pag. m.* 242.

BUT though (*Pyrophilus*) I have obſerved a red and green to be produced, the former, by acid ſalts, the latter by ſalts not acid, in the expreſt juices of ſo many differing vegetable ſubſtances, that the obſervation, if purſued, may prove (as I ſaid) of good uſe: yet to ſhow you how much even theſe effects depend upon the particular texture of bodies, I muſt ſubjoin ſome caſes wherein I (who am ſomewhat backwards to admit obſervations for univerſal) had the curioſity to diſcover, that the experiments would not uniformly ſucceed; and of theſe exceptions, the chief that I now remember, are reducible to the following three.

EXPERIMENT XXVI.

AND, (firſt) I thought fit to try the operation of acid ſalts upon vegetable ſubſtances, that are already and by their own nature red. And accordingly I made trial upon ſyrup of clove-julyflowers, the clear expreſſed juice of the ſucculent berries of *Spina Cervina*, or buckthorn, (which I had long kept by me for the ſake of its deep colour) upon red roſes, infuſion of Brazil, and divers other vegetable ſubſtances, on ſome of which cruſhed (as is often mentioned) upon white paper (which is alſo to be underſtood in moſt of theſe experiments, if no circumſtance of them argue otherwiſe) ſpirit of ſalt either made no conſiderable change, or altered the colour but from a darker to a lighter red. How it will ſucceed in many other vegetable juices, and infuſions of the ſame colour, I have at preſent ſo few at hand, that I muſt leave you to find it out your ſelf. But as for the operation of the other ſorts of ſalts upon theſe red ſubſtances, I found it not very uniform, ſome red, or reddiſh infuſions, as of roſes, being turned thereby into a dirty colour, but yet inclining to green. Nor was the ſyrup of clove-julyflowers turned by the ſolution of pot-aſhes to a much better, though ſomewhat a greener colour. Another ſort of red infuſions was by an alcaly not turned into a green, but advanced into a crimſon, as I ſhall have occaſion to note ere long. But there were other ſorts, as particularly the lovely coloured juice of buckthorn berries, that readily paſſed into a lovely green.

EXPERIMENT XXVII.

AMONG other vegetables, which we thought likely to afford exceptions to the general obſervation about the differing changes of colours produced by acid and ſulphureous ſalts, we thought fit to make trial upon the flowers of jaſmin, they being both white as to colour, and eſteemed to be of a more oily nature than other flowers. Whereupon having taken the white parts only of the flowers, and rubbed them ſomewhat hard with my finger, upon a piece of clean paper, it appeared very little diſcoloured. Nor had ſpirit of ſalt, wherewith I moiſtened one part of it, any conſiderable operation upon it. But ſpirit of urine, and ſomewhat more effectually a ſtrong alcalizate ſolution, did immediately turn the almoſt colourleſs paper moiſtened by the juice of the jaſmin, not as thoſe liquors are wont to do, when put upon the juices of other flowers, of a good green, but of a deep, though ſomewhat greeniſh yellow; which experiment I did afterwards at ſeveral times repeat with the like ſucceſs. But it ſeems not that a great degree of unctuouſneſs is neceſſary to the production of the like effects, for when we tried the experiment with the leaves of thoſe purely white flowers that appear about the end of winter, and are commonly called ſnow-drops, the event was not much unlike that, which we have been newly mentioning.

EXPERIMENT XXVIII.

ANOTHER ſort of inſtances to ſhow how much changes of colours, effected by ſalts, depend upon the particular texture of the coloured bodies, has been afforded me by ſeveral yellow flowers, and other vegetables, as mary-gold leaves, early primroſes, freſh madder, *&c.* For being rubbed upon white paper, till they imbued it with their colour, I found not, that by the addition of alcalizate liquors, nor yet by that of an urinous ſpirit, they would be turned either green or red: nor did

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did ſo acid a ſpirit as that of ſalt, conſiderably alter their colour, ſave that it ſeemed a little to dilute it: Only in ſome early primroſes it deſtroyed the greateſt part of the colour, and made the paper almoſt white again. And madder alſo afforded ſomething peculiar, and very differing from what we have newly mentioned: for having gathered ſome roots of it, and (whilſt they were recent) expreſſed upon white paper the yellow juice, an alcalizate ſolution dropt upon it did not turn it either green or white, but red. And the bruiſed madder itſelf being drenched with the like alcalizate ſolution, exchanged alſo its yellowiſhneſs for a redneſs.

An admonition touching the four preceding EXPERIMENTS.

HAVING thus (*Pyrophilus*) given you divers inſtances, to countenance the general obſervation delivered in the twenty fifth experiment, and divers exceptions whereby it ought to be limited; I muſt leave the further inquiry into theſe matters to your own induſtry. For not remembring at preſent many of thoſe other trials, long ſince made to ſatisfy my ſelf about particulars, and not having now the opportunity to repeat them, I muſt content my ſelf to have given you the hint, and the ways of proſecuting the ſearch your ſelf; and only declare to you in general, that, as I have made many trials, unmentioned in this treatiſe, whoſe events were agreeable to thoſe mentioned in the twenty-fifth experiment, ſo (to name now no other inſtances) what I have tried with acid and ſulphureous ſalts upon the pulp of juniper berries, rubbed upon white paper, inclines me to think, that among that vaſt multitude, and ſtrange variety of plants that adorn the face of the earth, perhaps many other vegetables may be found, on which ſuch menſtruums may not have ſuch operations, as upon the juice of violets, peas-bloſſoms, *&c.* no nor upon any of thoſe three other ſorts of vegetables, that I have taken notice of in the three foregoing experiments: it ſufficiently appearing even by theſe, that the effects of a ſalt upon the juices of particular vegetables do very much depend upon their particular textures.

EXPERIMENT XXIX.

IT may be of ſome uſe towards the diſcovery of the nature of theſe changes, which the alimental juice receives in ſome vegetables, according to the differing degrees of their maturity, and according to the differing kinds of plants of the ſame denomination, to obſerve what operation acid, urinous, and alcalizate ſalts will have upon the juices of the ſeveral ſorts of the vegetable ſubſtances I have been mentioning.

TO declare my meaning by an example; I took from the ſame cluſter one blackberry full ripe, and another that had not yet gone beyond a redneſs; and rubbing a piece of white paper, with the former, I obſerved that the juice adhering to it was of a dark reddiſh colour, full of little black ſpecks, and that this juice, by a drop of a ſtrong lixivium, was immediately turned into a greeniſh colour deep enough; by as much urinous ſpirit, into a colour much of kin to the former, though ſomewhat differing, and fainter; and by a drop of ſpirit of ſalt, into a fine and lightſome red: whereas the red berry being in like manner rubbed upon paper, left on it a red colour, which was very little altered by the acid ſpirit newly named, and by the urinous and lixiviate ſalts received changes of colour, differing from thoſe that had been juſt before produced in the dark juice of the ripe blackberry.

I REMEMBER alſo, that though the infuſion of damaſk roſes would as well, though not ſo much, as that of red, be heightened by acid ſpirits to an intenſe degree of redneſs, and by lixiviate ſalts be brought to a darkiſh green; yet having for trial's ſake taken a roſe, whoſe leaves, which were large and numerous, like thoſe of a *Provence* roſe, were perfectly yellow, though in a ſolution of ſalt of tartar, they afforded a green blueiſh tincture, yet I did not by an acid liquor obtain a red one; all that the ſaline ſpirit I employed performed, being (if I much miſ-remember not) to dilute ſomewhat the yellowneſs of the leaves. I would alſo have tried the tincture of yellow violets, but could procure none. And if I were in thoſe iſlands of *Banda*, which are made famous as well as rich, by being the almoſt only place where cloves will proſper, I ſhould think it worth my curioſity to try, what operation the three differing kinds of ſalts, I have ſo often mentioned, would have upon the juice of this ſpice, (expreſſed at the ſeveral ſeaſons of it) as it grows upon the tree. Since good authors inform us, (of what is remarkable) that theſe whether fruits, or rudiments of fruits, are at firſt white, afterward green, and then reddiſh, before they be beaten off the tree; after which being dried before they are put up, they grow blackiſh, as we ſee them. And one of the recenteſt Herbariſts informs us, that the flower grows upon the top of the clove itſelf, conſiſting of four ſmall leaves, like a cherry-bloſſom, but of an excellent blue. But (*Pyrophilus*) to return to our own obſervations, I ſhall add, that I the rather chuſe to mention to you an example drawn from roſes, becauſe that though I am apt to think, as I elſewhere advertiſe, that ſomething may be gueſſed at about ſome of the qualities of the juices of vegetables, by the reſemblance or diſparity that we meet with in the changes made of their colours, by the operation of the ſame kinds of ſalts; yet that thoſe conjectures ſhould be very warily made, may appear, among other things, by the inſtance I have choſen to give in roſes. For though, (as I formerly told you) the dried leaves, both of the damaſk, and of red ones, give a red tincture to water ſharpened with acid ſalts, yet the one ſort of leaves is known to have a purgative faculty, and the other are often, and divers ways employed for binding. *See* Parkinſon *Th. Botan. Trib.* 9. *cap.* 26.

AND I alſo chuſe (*Pyrophilus*) to ſubjoin this twenty-ninth experiment to thoſe that pre-

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cede it, about the change of the colours of vegetables by ſalts, for theſe two reaſons: the firſt, that you may not eaſily entertain ſuſpicions, if in the trials of an experiment of ſome of the kinds formerly mentioned, you ſhould meet with an event ſomewhat differing from what my relations may have made you expect. And the ſecond, that you may hereby be invited to diſcern, that it may not be amiſs to take notice of the particular ſeaſons wherein you gather the vegetables which in nicer experiments you make uſe of. For, if I were not hindered both by haſte and ſome juſtifiable conſiderations, I could perhaps add conſiderable inſtances, to thoſe lately delivered, for the making out of this obſervation; but for certain reaſons I ſhall at preſent ſubſtitute a remarkable paſſage to be met with in that laborious Herbariſt Mr. *Parkinſon*, where treating of the virtues of the (already divers times mentioned) buckthorn berries, he ſubjoins the following account of ſeveral pigments that are made of them, not only according to the ſeveral ways of handling them, but according to the differing ſeaſons of maturity, at which they are gathered. *Of theſe berries*, (ſays he) *are made three ſeveral ſorts of colours as they ſhall be gathered, that is, being gathered while they are green, and kept dry, are called ſapberries, which being ſteeped into ſome allom-water, or freſh bruiſed into allom-water, they give a reaſonable fair yellow colour which painters uſe for their work, and book binders to colour the edges of books, and leather-dreſſers to colour leather; as they uſe alſo to make a green colour, called ſap-green, taken from the berries when they are black, being bruiſed and put into a braſs or copper kettle or pan, and there ſuffered to abide three or four days, or a little heated upon the fire, and ſome beaten allom put unto them, and afterwards preſſed forth; the juice or liquor is uſually put into great bladders tied with ſtrong thread at the head and hung up until it be dry, which is diſſolved in water or wine, but ſack* (he affirms) *is the beſt to preſerve the colour from ſtarving, (as they call it) that is, from decaying, and make it hold freſh the longer. The third colour (whereof none*, ſays he, *that I can find have made mention but only* Tragus) *is a purpliſh colour, which is made of the berries ſuffered to grow upon the buſhes until the middle or end of* November, *that they are ready to drop from the trees.*

AND, I remember (*Pyrophilus*) that I tried, with a ſucceſs that pleaſed me well enough, to make ſuch a kind of pigment, as the painters call ſap-green, by a way not unlike that delivered here by our author, but I cannot now find any thing relating to that matter among my looſe papers. And my trials were made ſo many years ago, that I dare not truſt my memory for circumſtances, but will rather tell you, that in a noted colour-ſhop I brought them by queſtions to confeſs to me, that they made their ſap-green much after the ways by our Botaniſt here mentioned. And on this occaſion I ſhall add an obſervation, which though it does not ſtrictly belong to this place, may well enough be mentioned here; namely, that I find by an account given us by the learned *Cluſius*, of alaternus, that even the groſſer parts of the ſame plant are ſome of them one colour, and ſome another: for ſpeaking of that plant, he tells us, that the Portugals uſe the bark to dye their nets into a red colour, and with the chips of the wood, which are whitiſh, they dye a blackiſh blue.

EXPERIMENT XXX.

AMONG the experiments that tend to ſhew that the change of colours in bodies may proceed from the varied texture of their parts, and the conſequent change of their diſpoſition to reflect or refract the light, that ſort of experiments muſt not be left unmentioned, which is afforded us by chymical digeſtions. For, if chymiſts will believe ſeveral famous writers about what they call the philoſopher's ſtone, they muſt acknowledge that the ſame matter, ſealed up hermetically in a philoſophical egg, will, by the continuance of digeſtion, or if they will have it ſo (for it is not material in our caſe which of the two it be) of decoction, run through a great variety of differing colours, before it come to that of the nobleſt elixir; whether that be ſcarlet, or purple, or whatever other kind of red. But without building any thing on ſo obruſe and queſtionable an operation, (which yet may be pertinently repreſented to thoſe that believe the thing) we may obſerve, that divers bodies digeſted in carefully cloſed veſſels, will in tract of time change their colour: As I have elſewhere mentioned my having obſerved even in rectified ſpirit of hartſhorn, and as is evident in the precipitations of amalgams of gold and mercury, without addition, where, by the continuance of a due heat, the ſilver-coloured amalgam is reduced into a ſhining red powder. Further inſtances of this kind you may find here and there in divers places of my other eſſays. And indeed it has been a thing, that has much contributed to deceive many chymiſts, that there are more bodies than one, which by digeſtion will be brought to exhibit that variety and ſucceſſion of colours, which they imagine to be peculiar to what they call the *true matter of the philoſophers*. But concerning this, I ſhall refer you to what you may elſewhere find in the diſcourſe written touching the paſſive deceptions of chymiſts, and more about the production of colours by digeſtion you will meet with preſently. Wherefore I ſhall now make only this obſervation from what has been delivered, that in theſe operations there appears not any cauſe to attribute the new colours emergent to the action of a new ſubſtantial form, nor to any increaſe or decrement of either the ſalt, ſulphur, or mercury of the matter that acquires new colours: for the veſſels are cloſed, and theſe principles, according to the chymiſts, are ingenerable and incorruptible; ſo that the effect ſeems to proceed from hence, that the heat agitating and ſhuffling the corpuſcles of the body expoſed to it, does in proceſs of time ſo change its texture, as that the tranſpoſed parts

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do modify the incident light otherwiſe, than they did when the matter appeared of another colour.

EXPERIMENT XXXI.

AMONG the ſeveral changes of colour, which bodies acquire or diſcloſe by digeſtion, it is very remarkable, that chymiſts find a redneſs rather than any other colour in moſt of the tinctures they draw, and even in the more groſs ſolutions they make of almoſt all concretes, that abound either with mineral or vegetable ſulphur, though the menſtruum imployed about theſe ſolutions or tinctures be never ſo limpid or colourleſs.

THIS we have obſerved in I know not how many tinctures drawn with ſpirit of wine from jalap, guaiacum, and ſeveral other vegetables; and not only in the ſolutions of amber, benzoin, and divers other concretes made with the ſame menſtruum, but alſo in divers mineral tinctures. And, not to urge that familiar inſtance of the ruby of ſulphur, as chymiſts upon the ſcore of its colour call the ſolution of flowers of brimſtone, made with the ſpirit of turpentine, nor to take notice of other more known examples of the aptneſs of chymical oils to produce a red colour with the ſulphur they extract, or diſſolve; not to inſiſt (I ſay) upon inſtances of this nature, I ſhall further repreſent to you, as a thing remarkable, that both acid and alcalizate ſalts, though in moſt other caſes of ſuch contrary operations, in reference to colours, will, with many bodies that abound with ſulphureous, or with oily parts, produce a red; as is manifeſt partly in the more vulgar inſtances of the tinctures, or ſolutions of ſulphur made with lixiviums, either of calcined tartar or pot-aſhes, and other obvious examples, partly by this, that the true glaſs of antimony extracted with ſome acid ſpirits, with or without wine, will yield a red tincture, and that I know an acid liquor, which in a moment will turn oil of turpentine into a deep red. But among the many inſtances I could give you of the eaſy production of redneſs by the operation of ſaline ſpirit, as well as of ſpirit of wine; I remember two or three of thoſe I have tried, which ſeem remarkable enough to deſerve to be mentioned to you apart.

EXPERIMENT XXXII.

BUT before we ſet them down, it will not perhaps appear impertinent to premiſe,

THAT there ſeems to be a manifeſt diſparity betwixt red liquors, ſo that ſome of them may be ſaid to have a genuine redneſs in compariſon of others, that have a yellowiſh redneſs: for if you take (for example) a good tincture of cochineal, dilute it ever ſo much with fair water, you will not (as far as I can judge by what I have tried) be able to make it a yellow liquor. Inſomuch that a ſingle drop of a rich ſolution of cochineal in ſpirit of urine, being diluted with above an ounce of fair water, exhibited no yellowiſhneſs at all, but a fair (though ſomewhat faint) pink or carnation; and even when cochineal was by degrees diluted much beyond the newly mentioned colour, by the way formerly related to you in the twenty fourth experiment, I remember not, that there appeared in the whole trial any yellow. But if you take balſam of ſulphur (for inſtance) though it may appear in a glaſs, where it has a good thickneſs, to be of a deep red; yet if you ſhake the glaſs, or pour a few drops on a ſheet of white paper, ſpreading them on it with your finger, the balſam that falls back along the ſides of the glaſs, and that which ſtains the paper, will appear yellow, not red. And there are divers tinctures, ſuch as that of amber made with ſpirit of wine (to name now no more) that will appear either yellow or red, according as the veſſels that they fill, are ſlender or broad.

EXPERIMENT XXXIII.

BUT to proceed to the experiments I was about to deliver: Firſt, oil or ſpirit of turpentine, though clear as fair water, being digeſted upon the purely white ſugar of lead, has, in a ſhort time, afforded us a high red tincture, that ſome artiſts are pleaſed to call the balſam of *Saturn*, which they very much (and probably not altogether without cauſe) extol as an excellent medicine in divers outward affections.

EXPERIMENT XXXIV.

NEXT, take of common brimſtone finely powdered five ounces, of ſal-armoniac likewiſe pulverized an equal weight, of beaten quick-lime ſix ounces, mix theſe powders exquiſitely, and diſtil them through a retort placed in ſand by degrees of fire, giving at length as intenſe a heat as you well can in ſand; there will come over (if you have wrought well) a volatile tincture of ſulphur, which may probably prove an excellent medicine, and ſhould have been mentioned among the other preparations of ſulphur, which we have elſewhere imparted to you, but that it is very pertinent to our preſent ſubject, the change of colours. For though none of the ingredients be red, the diſtilled liquor will be ſo: and this liquor, if it be well drawn, will, upon a little agitation of the phial firſt unſtopped, (eſpecially if it be held in a warmer hand) ſend forth a copious fume, not red, like that of nitre, but white; and ſometimes this liquor may be ſo drawn, that I remember, not long ſince, I took pleaſure to obſerve in a parcel of it, that ingredients not red, did not only yield by diſtillation a volatile ſpirit that was red, but though that liquor did upon the bare opening of the bottle it was kept in, drive us away with the plenty and ſulphureous ſcent of a white ſteam which it ſent forth, yet the liquer itſelf being touched by our fingers, did immediately dye them black.

EXPERIMENT XXXV.

THE third and laſt experiment I ſhall now mention, to ſhew how prone bodies abounding in ſulphureous parts are to afford a red colour, is one, wherein by the operation of

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a ſaline ſpirit upon a white or whitiſh body, which according to the chymiſts ſhould be altogether ſulphureous, a redneſs may be produced, not (as in the former experiments) ſlowly, but in the twinkling of an eye. We took then of the eſſential oil of aniſeeds, which has this peculiarity, that in cold weather it loſes its fluidity and the greateſt part of its tranſparency, and looks like a white or whitiſh ointment, and near at hand ſeems to conſiſt of a multitude of little ſoft ſcales: of this coagulated ſtuff we ſpread a little with a knife upon a piece of white paper, and letting fall on it, and mixing with it, a drop or two of oil of vitriol, immediately (as we fore-ſaw) there emerged together with ſome heat and ſmoke, a blood-red colour which therefore was in a trice produced by two bodies, whereof the one had but a whitiſh colour, and the other (if carefully rectified) had no colour at all.

EXPERIMENT XXXVI.

BUT on this occaſion (*Pyrophilus*) we muſt add once for all, that in many of the above recited experiments, though the changes of colour happened as we have mentioned them; yet the emergent or produced colour is oft-times very ſubject to degenerate, both quickly and much. Notwithſtanding which, ſince the changes, we have ſet down, do happen preſently upon the operation of the bodies upon each other, or at the times by us ſpecified, that is ſufficient both to juſtify our veracity, and to ſhew what we intend; it not being eſſential to the genuineneſs of a colour to be durable. For a fading leaf, that is ready to rot, and moulder into duſt, may have as true a yellow, as a wedge of gold, which ſo obſtinately reſiſts both time and fire. And the reaſon why I take occaſion from the former experiment to ſubjoin this general advertiſement, is, that I have ſeveral times obſerved, that the mixture reſulting from the oils of vitriol, and of aniſeeds, though it acquire a thicker conſiſtence than either of the ingredients had, has quickly loſt its colour, turning in a very ſhort time into a dirty grey, at leaſt in the ſuperficial parts, where it is expoſed to the air: which laſt circumſtance I therefore mention, becauſe that, though it ſeem probable, that this degeneration of colours may oft-times and in divers caſes proceed from the further action of the ſaline corpuſcles, and the other ingredients upon one another, yet in many caſes much of the quick change of colours ſeems aſcribeable to the air, as may be made probable by ſeveral reaſons: the firſt whereof may be fetched from the newly recited example of the two oils; the next may be, that we have ſometimes obſerved long window-curtains of light colours to have that part of them, which was expoſed to the air, when the window was open of one colour, and the lower part, that was ſheltered from the air by the wall, of another colour: and the third argument may be fetched from divers obſervations, both of others, and our own; for of that pigment ſo well known in painters ſhops, by the name of Turnſol, our induſtrious *Parkinſon*, in the particular account he gives of the plant that bears it, tells us alſo, That *the berries, when they are at their full maturity, have within them between the outer ſkin and the inward kernel or ſeed, a certain juice or moiſture, which being rubbed upon paper or cloth, at the firſt appears of a freſh and lovely green colour, but preſently changeth into a kind of blueiſh purple, upon the cloth or paper; and the ſame cloth afterwards wet in water, and wrung forth, will colour the water into a claret-wine colour; and theſe* (concludes he) *are thoſe rags of cloth, which are uſually called* turnſol *in the druggiſts or grocers ſhops.* And to this obſervation of our Botaniſt we will add an experiment of our own, (made before we met with that) which, though in many circumſtances very differing, ſerves to prove the ſame thing. For having taken of the deeply red juice of buckthorn berries, which I bought of the man that uſes to ſell it to the apothecaries, to make their ſyrup *de ſpina cervina*, I let ſome of it drop upon a piece of white paper, and having left it there for many hours, till the paper was grown dry again, I found what I was inclined to ſuſpect, namely, that this juice was degenerated from a deep red to a dirty kind of greyiſh colour, which, in a great part of the ſtained paper, ſeemed not to have ſo much as an eye of red: though a little ſpirit of ſalt or diſſolved alcali would turn this unpleaſant colour (as formerly I told you it would change the not yet altered juice) into a red or green. And to ſatisfy my ſelf, that this degeneration of colour did not proceed from the paper, I dropped ſome of the deep red or crimſon juice upon a white glazed tile, and ſuffering it to dry on there, I found that even in that body, on which it could not ſoak, and by which it could not be wrought, it nevertheleſs loſt its colour. And theſe inſtances (*Pyrophilus*) I am the more careful to mention to you, that you may not be much ſurpriſed or diſcouraged, if you ſhould ſometimes miſs of performing punctually what I affirm my ſelf to have done in point of changing colours; ſince in theſe experiments the over-ſight or neglect of ſuch little circumſtances, as in many others would not be perhaps conſiderable, may occaſion the miſ-carrying of a trial. And I was willing alſo to take this occaſion of advertiſing you in the repeating of the experiments mentioned in the treatiſe, to make uſe of the juices of vegetables, and other things prepared for your trials, as ſoon as ever they are ready, leſt one or other of them grow leſs fit, if not quite unfit by delay; and to eſtimate the event of trials by the change, that is produced preſently upon the due and ſufficient application of actives to paſſives, (as they ſpeak) becauſe in many caſes the effects of ſuch mixtures may not be laſting, and the newly produced colour may in a little time degenerate. But (*Pyrophilus*) I forgot to add to the former obſervations lately made about vegetables, a third of the ſame import, made in mineral ſubſtances, by telling you, that the better to ſatisfy a friend or two in this particular, I ſometimes made, according to ſome conjectures of mine, this experiment;

Parkinſon, *Theat. Bot. Trib.* 4. *cap.* 12.

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experiment; that having diſſolved good ſilver in aqua-fortis, and precipitated it with ſpirit of ſalt, upon the firſt decanting of the liquor, the remaining matter would be purely white; but after it had lain a while uncovered, that part of it that was contiguous to the air, would not only loſe its whiteneſs, but appear of a very dark and almoſt blackiſh colour; I ſay, that part that was contiguous to the air, becauſe if that were gently taken off, the ſubjacent part of the ſame maſs would appear very white, till that alſo, having continued a while expoſed to the air, would likewiſe degenerate. Now whether the air perform theſe things by the means of a ſubtile ſalt, which we elſewhere ſhew it not to be deſtitute of, or by a piercing moiſture, that is apt eaſily to inſinuate it ſelf into the pores of ſome bodies, and thereby change their texture, and ſo their colour; or by ſolliciting the avolation of certain parts of the bodies, to which it is contiguous; or by ſome other way, (which poſſibly I may elſewhere propoſe and conſider) I have not now the leiſure to diſcourſe. And for the ſame reaſon, though I could add many other inſtances, of what I formerly noted touching the emergency of redneſs upon the digeſtion of many bodies, inſomuch that I have often ſeen upon the borders of *France* (and probably we may have the like in *England*) a ſort of pears, which digeſted for ſome time with a little wine, in a veſſel exactly cloſed, will in not many hours appear throughout of a deep red colour, (as alſo that of the juice, wherein they are ſtewed, becomes) but even on pure and white ſalt of tartar, pure ſpirit of wine, as clear as rock-water, will (as we elſewhere declare) by long digeſtion acquire a redneſs: though I ſay ſuch inſtances might be multiplied, and though there be ſome other obvious changes of colours, which happen ſo frequently, that they cannot but be as well conſiderable as notorious; ſuch as is the blackneſs of almoſt all bodies burned in the open air; yet our haſte invites us to reſign you the exerciſe of inquiring into the cauſes of theſe changes. And certainly, the reaſon both why the ſoots of ſuch differing bodies are almoſt all of them all black, why ſo much the greater part of vegetables ſhould be rather green than of any other colour, and particularly (which more directly concerns the place) why gentle heats do ſo frequently in chymical operations produce rather a redneſs than any other colour in digeſted menſtruums, not only ſulphureous, as ſpirit of wine, but ſaline, as ſpirit of vinegar, may be very well worth a ſerious inquiry; which I ſhall therefore recommend to *Pyrophilus* and his ingenious friends.

EXPERIMENT XXXVII.

IT may ſeem ſomewhat ſtrange, that if you take the crimſon ſolution of cochineal, or the juice of black cherries, and of ſome other vegetables that afford the like colour, (which becauſe many take but for a deep red, we do with them ſometimes call it ſo) and let ſome of it fall upon a piece of paper, a drop or two of an acid ſpirit, ſuch as ſpirit of ſalt, or aqua-fortis, will immediately turn it into a fair red. Whereas, if you make an infuſion of brazil in fair water, and drop a little ſpirit of ſalt or aqua-fortis into it, that will deſtroy its redneſs, and leave the liquor of a yellow, (ſometimes pale) I might perhaps plauſibly enough ſay on this occaſion, that if we conſider the caſe a little more attentively, we may take notice, that the action of the acid ſpirit ſeems in both caſes but to weaken the colour of the liquor on which it falls. And ſo though it deſtroy redneſs in the tincture of brazil, as well as produce red in the tincture of cochineal, its operations may be uniform enough, ſince as crimſon ſeems to be little elſe than a very deep red, with (perhaps) an eye of blue, ſo ſome kinds of red ſeem (as I have lately noted) to be little elſe than heightned yellow. And conſequently in ſuch bodies, the yellow ſeems to be but a diluted red. And accordingly alcalizate ſolutions and urinous ſpirits, which ſeem diſpoſed to deepen the colours of the juices and liquors of moſt vegetables, will not only reſtore the ſolution of cochineal and the infuſion of brazil to crimſon, whence the ſpirit of ſalt had changed them into a truer red; but will alſo (as I lately told you) not only heighten the yellow juice of madder into red, but advance the red infuſion of brazil to a crimſon. But I know not whether it will not be much ſafer to derive theſe changes from varied textures, than certain kinds of bodies; and you will perhaps think it worth while, that I ſhould add on this occaſion, that it may deſerve ſome ſpeculation, why notwithſtanding what we have been obſerving, though blue and purple ſeem to be deeper colours than red, and therefore the juices of plants of either of the two former colours may (congruouſly enough to what has been juſt now noted) be turned red by ſpirit of ſalt or aqua-fortis, yet blue ſyrup of violets and ſome purples ſhould both by oil of tartar and ſpirit of urine be changed into green, which ſeems to be not a deeper, but a more diluted colour than blue, if not alſo than purple.

EXPERIMENT XXXVIII.

IT would much contribute to the hiſtory of colours, if chymiſts would in their laboratories take a heedful notice, and give us a faithful account of the colours obſerved in the ſteams of bodies either ſublimed or diſtilled, and of the colours of thoſe productions of the fire, that are made up by the coalition of thoſe ſteams. As (for inſtance) we obſerve in the diſtilling of pure ſalt-petre, that at a certain ſeaſon of the operation, the body, though it ſeem either cryſtalline, or white, affords very red fumes: whereas though vitriol be green or blue, the ſpirit of it is obſerved to come over in whitiſh fumes. The like colour I have taken notice of in the fumes of ſeveral other concretes of differing colours, and natures, eſpecially when diſtilled with ſtrong

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fires. And we elſewhere note, that even ſoot, as black as it is, has filled our receivers with ſuch copious white fumes, that they ſeemed to have had their inſides waſhed with milk. And no leſs obſervable may be the diſtilled liquors, into which ſuch fumes convene, (for though we will not deny, that by ſkill and care a reddiſh liquor may be obtained from nitre) yet the common ſpirit of it, in the making even of which, ſtore of theſe red ſumes are wont to paſs over into the receiver, appears not to be at all red. And beſides, that neither the ſpirit of vitriol, nor that of ſoot is any thing white; and, beſides alſo, that as far as I have obſerved, moſt (for I ſay not all) of the empyreumatical oils of wood, and other concretes, are either of a deep red, or of a colour between red and black; beſides this, I ſay, it is very remarkable, that notwithſtanding that great variety of colours to be met with in the herbs, flowers, and other bodies wont to be diſtilled *in balneo*; yet (as far at leaſt as our common diſtillers experience reacheth) all the waters and ſpirits that firſt come over by that way of diſtillation, leave the colours of their concretes behind them, though indeed there be one or two vegetables not commonly taken notice of, whoſe diſtilled liquors I elſewhere obſerve to carry over the tincture of the concrete with them. And as in diſtillations, ſo in ſublimations, it were worth while to take notice of what comes up, in reference to our preſent ſcope, but purpoſely performing them (as I have in ſome caſes done) in conveniently ſhaped glaſſes, that the colour of the aſcending ſumes may be diſcerned; for it may afford a Naturaliſt good information to obſerve the congruities or the differences betwixt the colours of the aſcending fumes, and thoſe of the flowers they compoſe by their convention. For it is evident, that theſe flowers do many of them, in point of colour, much differ, not only from one another, but oft times from the concretes that afforded them. Thus, (not here to repeat what I formerly noted of the black ſoots of very differingly coloured bodies) though camphire and brimſtone afford flowers much of their own colour, ſave that thoſe of brimſtone are wont to be a little paler, than the lumps that yielded them; yet even of red benzoin, that ſublimed ſubſtance, which chymiſts call its flowers, is wont to be white or whitiſh. And to omit other inſtances, even one and the ſame black mineral, antimony, may be made to afford flowers, ſome of them red, and ſome grey, and, which is more ſtrange, ſome of them purely white. And it is the preſcription of ſome glaſs-men by exquiſitely mingling a convenient proportion of brimſtone, ſal-armoniack, and quickſilver, and ſubliming them together, to make a ſublimate of an excellent blue; and though having cauſed the experiment to be made, we found the produced ſublimate to be far from being of a lovely colour, (as was promiſed) that here and there it ſeemed blueiſh, and at leaſt was of a colour differing enough from either of the ingredients, which is ſufficient for our preſent purpoſe. But a much finer colour is promiſed by ſome of the empiricks, that pretend to ſecrets, who tell us, that orpiment being ſublimed, will afford among the parts of it that fly upward, ſome little maſſes, which, though the mineral itſelf be of a good yellow, will be red enough to emulate rubies, both in colour and tranſlucency. And this experiment may, for aught I know, ſometimes ſucceed; for I remember, that having in a ſmall bolt-head purpoſely ſublimed ſome powdered orpiment, we could in the lower part of the ſublimate diſcern here and there ſome reddiſh lines, though much of the upper part of the ſublimate conſiſted of a matter, which was not alone purely yellow, but tranſparent almoſt like a powder. And we have alſo this way obtained a ſublimate, the lower part whereof though it conſiſted not of rubies, yet the ſmall pieces of it, which were numerous enough, were of a pleaſant reddiſh colour, and gliſtered very prettily. But to inſiſt on ſuch kind of trials and obſervations, (where the aſcending fumes of bodies differ in colour from the bodies themſelves) though it might indeed enrich the hiſtory of colours, would rob me of too much of the little time I have to diſpatch what I have further to tell you concerning them.

EXPERIMENT XXXIX.

TAKE the dried buds (or bloſſoms) of the pomegranate tree, (which are commonly called in the ſhops *Balauſtiums*;) pull off the reddiſh leaves, and by a gentle ebullition of them in fair water, or by a competent infuſion of them in like water well heated, extract a faint reddiſh tincture; which, if the liquor be turbid, you may clarify it by filtrating it. Into this, if you pour a little good ſpirit of urine, or ſome other ſpirit abounding in the like ſort of volatile ſalts, the mixture will preſently turn of a darkiſh green colour; but if inſtead of the forementioned liquor, you drop into the ſimple infuſion a little rectified ſpirit of ſea-ſalt, the pale and almoſt colourleſs liquor will immediately not only grow more tranſparent, but acquire a high redneſs, like that of rich claret wine; which ſo ſuddenly acquired colour may as quickly be deſtroyed, and turned into a dirty blueiſh green, by the affuſion of a competent quantity of the abovementioned ſpirit of urine.

ANNOTATION.

THIIS experiment may bring ſome light to, and receive ſome from a couple of other experiments, that I remember I have met with in the ingenious *Gaſſendus*'s animadverſions upon *Epicurus*'s philoſophy, whilſt I was turning over the leaves of thoſe learned commentaries, (my eyes being too weak to let me read ſuch voluminous books quite through;) and I the leſs ſcruple (notwithſtanding my contrary cuſtom in this treatiſe) to ſet down theſe experiments of another, becauſe I ſhall a little improve the latter of them, and becauſe by comparing therewith that which I have laſt cited, we may be aſſiſted to conjecture upon what account

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account it is, that oil of vitriol heightens the tincture of red-roſe leaves, ſince ſpirit of ſalt, which is a highly acid menſtruum, but otherwiſe differing enough from oil of vitriol, does the ſame thing. Our author's experiments then, as we made them, are theſe: We took about a glaſs-full of lukewarm water, and in it immerged a quantity of the leaves of ſenna, and preſently upon the immerſion there did not appear any redneſs in the water, but dropping into it a little oil of tartar, the liquor ſoon diſcovered a redneſs to the watchful eye; whereas by a little of that acid liquor of vitriol, which is like the former undeſervedly called oil, ſuch a colour would not be extracted from the infuſed ſenna. On the other ſide, we took ſome red-roſe leaves dried, and having ſhaken them into a glaſs of fair water, they imparted to it no redneſs, but upon the affuſion of a little oil of vitriol the water was immediately turned red, which it would not have been, if inſtead of oil of vitriol, we had employed oil of tartar to produce that colour. That theſe were *Gaſſendus* his experiments, I partly remember, and was aſſured by a friend, who lately tranſcribed them out of *Gaſſendus* his book, which, I therefore add, becauſe I have not now that book at hand. And the deſign of *Gaſſendus* in theſe experiments our friend affirms to be, to prove, that of things not red a redneſs may be made only by mixture, and the varied poſition of parts, wherein the doctrine of that ſubtile philoſopher doth not a little authorize what we have formerly delivered concerning the emergency and change of colours. But the inſtances, that we have out of him ſet down, ſeem not to be the moſt eminent, that may be produced of this truth: for our next experiment will ſhew the production of ſeveral colours out of liquors, which have not any of them any ſuch colour, nor indeed any diſcernable one at all. And whereas though our author tells us, that there was no redneſs either in the water, or the leaves of ſenna, or the oil of tartar; and though it be true, that the predominant colour of the leaves of ſenna be another than red, yet we have tried, that by ſteeping that plant a night even in cold water, it would afford a very deep yellow or reddiſh tincture without the help of the oil of tartar, which ſeems to do little more than aſſiſt the water to extract more nimbly a plenty of that red tincture, wherewith the leaves of ſenna do of themſelves abound, and having taken off the tincture of ſenna, made only with fair water, before it grew to be reddiſh, and decanted it from the leaves, we could not perceive, that by dropping ſome oil of tartar into it, that colour was conſiderable, though it were a little heightened into a redneſs, which might have been expected, if the particles of the oil did eminently co-operate, otherwiſe than we have expreſſed, to the production of this redneſs.

And as for the experiment with red-roſe leaves, the ſame thing may be alledged; for we found that ſuch leaves, by bare infuſion for a night and day in fair water, did afford us a tincture bordering at leaſt upon redneſs; and that colour being conſpicuous in the leaves themſelves, would not by ſome ſeem ſo much to be produced as to be extracted by the affuſion of oil of vitriol. And the experiment tried with the dry leaves of damaſk roſes ſucceeded but imperfectly, but that is indeed obſervable to our author's purpoſe, that oil of tartar will not perform in this experiment what oil of vitriol doth: but becauſe this laſt named liquor is not ſo eaſily to be had, give me leave to advertiſe you, that the experiment will ſucceed, if inſtead of it you employ aqua fortis. And though ſome trials of our own formerly made, and others eaſily deducible from what we have already delivered, about the different families and operations of ſalt, might enable us to preſent you an experiment upon red-roſe leaves, more accommodated to our author's purpoſe than that which he hath given us; yet our reverence to ſo candid a philoſopher, invites us rather to improve his experiment, than ſubſtitute another in its place. Take therefore of the tincture of red-roſe leaves, (for with damaſk-roſe leaves the experiment ſucceedeth not well) made as before hath been taught with a little oil of vitriol, and a good quantity of fair water; pour off this liquor into a clear phial half filled with limpid water, till the water held againſt the light have acquired a competent redneſs, without loſing its tranſparency; into this tincture drop leiſurely a little good ſpirit of urine, and ſhaking the phial, which you muſt ſtill hold againſt the light, you ſhall ſee the red liquor immediately turned into a fine greeniſh blue, which colour was not to be found in any of the bodies, upon whoſe mixture it emerged: and this change is the more obſervable, becauſe in many bodies the degenerating of blue into red is uſual enough, but the turning of red into blue is very unfrequent. If at every drop of ſpirit of urine you ſhake the vial containing the red tincture, you may delightfully obſerve a pretty variety of colours in the paſſage of that tincture from a red to a blue, and ſometimes we have this way hit upon ſuch a liquor, as being looked upon againſt and from the light, did ſeem faintly to emulate the abovementioned tincture of *Lignum Nephriticum*. And if you make the tincture of red-roſes very high, and, without diluting it with fair water, pour on the ſpirit of urine, you may have a blue ſo deep as to make the liquor opacous; but being dropt upon white paper, the colour will ſoon diſcloſe itſelf. Alſo having made the red, and conſequently the blue tincture very tranſparent, and ſuffered it to reſt in a ſmall open phial for a day or two, we found, according to our conjecture, that not only the blue, but the red colour alſo vaniſhed; the clear liquor being of a bright amber colour, at the bottom of which ſubſided a light, but copious feculency of almoſt the ſame colour, which ſeems to be nothing but the tincted parts of the roſe-leaves drawn out by the acid ſpirits of the oil of vitriol, and precipitated by the volatile ſalt of the ſpirit of urine: which makes it the more probable, that the redneſs drawn by the oil of vitriol, was at leaſt as well an extraction of the tinging parts of the roſes, as a production of redneſs. And laſtly, if you be

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be deſtitute of ſpirit of urine, you may change the colour of the tincture of roſes with many other ſulphureous ſalts, as a ſtrong ſolution of pot-aſhes, oil of tartar, *&c.* which yet are ſeldom ſo free from feculency, as the ſpirituous parts of urine becomes by repeated diſtillation.

ANNOTATION.

ON this occaſion, I call to mind, that I found a way of producing, though not the ſame kind of blue, as I have been mentioning, yet a colour near of kin to it, namely, a fair purple, by imploying a liquor not made red by art, inſtead of the tincture of red-roſes made with an acid ſpirit: and my way was, only to take log-wood, (a wood very well known to dyers) having by infuſion the powder of it a while in fair water made that liquor red, I dropt into it a tantillum of an urinous ſpirit, as that of ſal-armoniack, (and I have done the ſame thing with an alcali) by which the colour was in a moment turned into a rich, and lovely purple. But care muſt be had, that you let not fall into a ſpoonful above two or three drops, leſt the colour become ſo deep, as to make the liquor too opacous. And (to anſwer the other part of *Gaſſendus* his experiment) if inſtead of fair water, I infuſed the logwood in water made ſomewhat ſour by the acid ſpirit of ſalt, I ſhould obtain neither a purple liquor, nor a red, but only a yellow one.

EXPERIMENT XL.

THE experiment I am now to mention to you, *Pyrophilus*, is that which both you, and all the other Virtuoſi that have ſeen it, have been pleaſed to think very ſtrange; and indeed of all the experiments of colours I have yet met with, it ſeems to be the fitteſt to recommend the doctrine propoſed in this treatiſe, and to ſhew that we need not ſuppoſe, that all colours muſt neceſſarily be inherent qualities, flowing from the ſubſtantial forms of the bodies they are ſaid to belong to, ſince by a bare mechanical change of texture in the minute parts of bodies, two colours may in a moment be generated quite *de novo*, and utterly deſtroyed. For there is this difference betwixt the following experiment, and moſt of the others delivered in theſe papers, that in this, the colour that the body already had, is not changed into another, but betwixt two bodies, each of them apart devoid of colour, there is in a moment generated a very deep colour, and which if it were let alone, would be permanent; and yet by a very ſmall parcel of a third body, that has no colour of its own, (leſt ſome may pretend I know not what antipathy betwixt colours) this otherwiſe permanent colour will be in another trice ſo quite deſtroyed, that there will remain no foot-ſteps either of it or of any other colour in the whole mixture.

THE experiment is very eaſy, and it is thus performed: Take good common ſublimate, and fully ſatiate with it what quantity of water you pleaſe, filtre the ſolution carefully through clean and cloſe paper, that it may drop down as clear and colourleſs as fountain water. Then, when you'll ſhew the experiment, put of it about a ſpoonful into a ſmall wine-glaſs, or any other convenient veſſel made of clear glaſs, and dropping in three or four drops of good oil of tartar *per deliquium*, well filtred, that it may likewiſe be without colour: theſe two limpid liquors will in the twinkling of an eye turn into an opacous mixture of a deep orange colour, which by keeping the glaſs continually ſhaking in your hand, you muſt preſerve from ſettling too ſoon to the bottom; and when the ſpectators have a little beheld this firſt change, then you muſt preſently drop in about four or five drops of the oil of vitriol, and continuing to ſhake the glaſs pretty ſtrongly, that it may the nimbler diffuſe it ſelf, the whole colour, if you have gone ſkilfully to work, will immediately diſappear, and all the liquor in the glaſs will be clear and colourleſs as before, without ſo much as a ſediment at the bottom. But for the more graceful trial of this experiment, it will not be amiſs to obſerve, firſt, that there ſhould not be taken too much of the ſolution of ſublimate, nor too much of the oil of tartar dropped in, to avoid the neceſſity of putting in ſo much oil of vitriol as may make an ebullition, and perhaps run over the glaſs. Secondly, that it is convenient to keep the glaſs always a little ſhaking, both for the better mixing of the liquors, and to keep the yellow ſubſtance from ſubſiding, which elſe it would in a ſhort time do; though when it is ſubſided it will retain its colour, and alſo be capable of being deprived of it by the oil newly mentioned. Thirdly, that if any yellow matter ſtick at the ſides of the glaſs, it is but inclining the glaſs, till the clarified liquor can waſh along it, and the liquor will preſently imbibe it, and deprive it of its colour.

MANY have ſometimes wondered, how I came to light upon this experiment; but the notions or conjectures I have about the differing natures of the ſeveral tribes of ſalts, having led me to deviſe the experiment, it will not be difficult for me to give you the chymical reaſon, if I may ſo ſpeak, of the phænomenon. Having then obſerved, that mercury, being diſſolved in ſome menſtruums, would yield a dark yellow precipitate, and ſuppoſing that, as to this, common water, and the ſalts that ſtick to the mercury would be equivalent to thoſe acid menſtruums, which work upon the quickſilver, upon the account of their ſaline particles, I ſubſtituted a ſolution of ſublimate in fair water, inſtead of a ſolution of mercury in aqua-fortis, or ſpirit of nitre, that ſimple ſolution being both clearer and free from that very offenſive ſmell, which accompanies the ſolutions of mercury made with thoſe other corroſive liquors. Then I conſidered, that that which makes the yellow colour, is indeed but a precipitate made by the means of the oil of tartar, which we drop in, and which, as the chymiſts know, does generally precipitate metalline bodies

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bodies corroded by acid ſalts: ſo that the colour in our caſe reſults from the coalition of the mercurial particles with the ſaline ones, wherewith they were formerly aſſociated, and with the alcalizate particles of the ſalt of tartar that ſwim up and down in the oil. Wherefore conſidering alſo, that very many of the effects of lixiviate liquors, upon the ſolutions of other bodies, may be deſtroyed by acid menſtruums, as I elſewhere more particularly declare, I concluded, that if I choſe a very potently acid liquor, which by its inciſive power might undo the work of the oil of tartar, and diſperſe again thoſe particles, which the other had by precipitation aſſociated, into ſuch minute corpuſcles as were before ſingly inconſpicuous, they would become inconſpicuous again, and conſequently leave the liquor as colourleſs as before the precipitation was made.

THIS, as I ſaid, *Pyrophilus*, ſeems to be the chymical reaſon of this experiment; that is ſuch a reaſon, as, ſuppoſing the truth of thoſe chymical notions I have elſewhere I hope evinced, may give ſuch an account of the phænomena as chymical notions can ſupply us with: but I both here and elſewhere make uſe of this way of ſpeaking, to intimate that I am ſufficiently aware of the difference betwixt a chymical explication of a phænomenon, and one that is truly philoſophical or mechanical; as in our preſent caſe, I tell you ſomething, when I tell you that the yellowneſs of the mercurial ſolution, and the oil of tartar, is produced by the precipitation occaſioned by the affuſion of the latter of thoſe liquors, and that the deſtruction of the colour proceeds from the diſſipation of that curdled matter, whoſe texture is deſtroyed, and which is diſſolved into minute and inviſible particles by the potently acid menſtruum: which is the reaſon, why there remains no ſediment in the bottom, becauſe the infuſed oil takes it up, and reſolves it into hidden or inviſible parts, as water does ſalt or ſugar. But when I have told you all this, I am far from thinking I have told all that ſuch an inquiſitive perſon as your ſelf would know: for I preſume you would deſire, as well as I, to learn (at leaſt) why the particles of the mercury, of the tartar, and of the acid ſalts convening together, ſhould make rather an orange colour than a red, or a blue, or a green. For it is not enough to ſay what I related a little before, that divers mercurial ſolutions, though otherwiſe made, would yield a yellow precipitate, becauſe the queſtion will recur concerning them; and to give it a ſatisfactory anſwer, is, I freely acknowledge, more than I dare as yet pretend to.

BUT to confirm my conjecture about the chymical reaſon of our experiment, I may add, that as I have (*viz.* pag. 11. of this treatiſe) elſewhere (on another occaſion) told you, with ſaline liquors of another kind and nature than ſalt of tartar, (namely, with ſpirit of urine, and liquors of kin to that) I can make the mercury precipitate out of the firſt ſimple ſolution quite of another colour than that hitherto mentioned; nay, if inſtead of altering the precipitating liquor, I altered the texture of the ſublimate in ſuch a way as my notions about ſalt required, I could produce the ſame phænomenon. For having purpoſely ſublimed together equal parts (or thereabout) of ſal-armoniack and ſublimate, firſt diligently mixed, the aſcending flowers being diſſolved in fair water, and filtred, gave a ſolution limpid and colourleſs, like that of the other ſublimates, and yet an alcaly dropped into this liquor did not turn it yellow but white. And upon the ſame grounds we may with quickſilver, without the help of common ſublimate, prepare another ſort of flowers diſſoluble in water without diſcolouring it, with which I could likewiſe do what I newly mentioned; to which I ſhall add, (what poſſibly you will ſomewhat wonder at) that ſo much does the colour depend upon the texture reſulting from the convention of the ſeveral ſorts of corpuſcles, that though, in our experiment, oil of vitriol deſtroys the yellow colour, yet with quickſilver and fair water, by the help of oil of vitriol alone, we may eaſily make a kind of precipitate of a fair and permanent yellow, as you will ere long (in the forty ſecond experiment of this third part) be taught. And I may further add, that I choſe oil of vitriol, not ſo much for any other or peculiar quality, as for its being, when it is well rectified, (which it is ſomewhat hazardous to bring it to be) not only devoid of colour and ill ſmells, but extremely ſtrong and inciſive. For though common and undephlegmated aqua fortis will not perform the ſame thing well, yet that which is made exceeding ſtrong, by being carefully dephlegmed, will do it pretty well, though not ſo well as oil of vitriol; which is ſo ſtrong, that even without rectification it may for a need be made uſe of. I will not here tell you what I have tried, that I may be able to deprive at pleaſure the precipitate that one of the ſulphureous liquors had made, by the copious affuſion of the other; becauſe I found, though this experiment is too tickliſh to let me give a full account of it in few words, I ſhall therefore tell you, that it is not only for once, that the other above-mentioned experiment may be made, the ſame numerical parcels of liquor being ſtill employed in it. For after I have clarified the orange-coloured liquor, by the addition of as little of the oil of vitriol as will ſuffice to perform the effect, I can again at pleaſure reproduce the opacous colour, by the dropping in of freſh oil of tartar, and deſtroy it again by the re-affuſion of more of the acid menſtruum; and yet oftener, if I pleaſe, can I with theſe two contrariant liquors recall and diſperſe the colour, though by reaſon of the addition of ſo much new liquor, in reference to the mercurial particles, the colour will at length appear more dilute and faint.

An Improvement of the fortieth EXPERIMENT.

AND, *Pyrophilus*, to confirm yet further the notions that led me to think on the propoſed experiment, I ſhall acquaint you with another; which, when I had conveniency, I have ſometimes added to it, and which has to the ſpectators appeared little leſs odd than the firſt. And though becauſe the liquor, requiſite to make the trial ſucceed well, muſt be on pur-

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poſe prepared a-new a while before, becauſe it will not long retain its fitneſs for this work, I do but ſeldom annex this experiment to the other; yet I ſhall tell you how I deviſed it, and how I make it. If you boil crude antimony in a ſtrong and clear lixivium, you ſhall ſeparate a ſubſtance from it, which ſome modern chymiſts are pleaſed to call its ſulphur, but how deſervedly I ſhall not here examine, having elſewhere done it in an opportune place; wherefore I ſhall now but need to take notice, that when this ſuppoſed ſulphur (not now to call it rather a kind of crocus) is let fall by the liquor upon its refrigeration, it often ſettles in flakes, or ſuch-like parcels of a yellow ſubſtance, (which being by the precedent diſſolution reduced into minute parts, may peradventure be made to take fire much more eaſily than the groſſer powder of unprepared antimony would have done.) Conſidering therefore, that common ſulphur boiled in a lixivium, may be precipitated out of it by rheniſh-wine or white-wine, which are ſouriſh liquors, and have in them, as I elſewhere ſhew, an acid ſalt; and having found alſo by trial, that with other acid liquors I could precipitate out of lixiviate ſolvents ſome other mineral concretions abounding with ſulphureous parts, of which ſort is crude antimony; I concluded it to be eaſy to precipitate the antimony diſſolved, as was lately mentioned, with the acid oil of vitriol. And though common ſulphur yields a white precipitate, which the chymiſts call *lac ſulphuris*, yet I ſuppoſed the precipitated antimony would be of a deep yellow colour, as well if made with oil of vitriol, as if made only by refrigeration and length of time. From this it was eaſy to deduce this experiment, that if you put into one glaſs ſome of the freſhly impregnated and filtrated ſolution of antimony, and into another ſome of the orange-coloured mixture, (which I formerly ſhewed you how to make with a mercurial ſolution and oil of tartar) a few drops of oil of vitriol dropped into the laſt mentioned glaſs would, as I told you before, turn the deep yellow mixture into a clear liquor; whereas a little of the ſame oil dropped out of the ſame phial into the other glaſs, would preſently (but not without ſome ill ſcent) turn the moderately clear ſolution into a deep yellow ſubſtance. But this, as I ſaid, ſucceeds not well, unleſs you employ a lixivium that has but newly diſſolved antimony, and has not yet let it fall. But yet in ſummer-time, if your lixivium have been duly impregnated and well filtred after it is quite cold, it will for ſome days (perhaps much longer than I had occaſion to try) retain antimony enough to exhibit, upon the affuſion of the corroſive oil, as much of a good yellow ſubſtance as is neceſſary to ſatisfy the beholders of the poſſibility of the experiment.

Reflections upon the XLth experiment, compared with the Xth and XXth.

THE knowledge of the diſtinction of ſalts which we have propoſed, whereby they are diſcriminated into acid, volatile, or ſalſuginous (if I may for diſtinction ſake ſo call the fugitive ſalts of animal ſubſtances) and fixed or alcalizate, may poſſibly (by that little part which we have already delivered, of what we could ſay of its applicableneſs) appear of ſo much uſe in natural philoſophy (eſpecially in the practick part of it) that I doubt not but it will be no unwelcome corollary of the preceding experiment, if by the help of it I teach you to diſtinguiſh which of thoſe ſalts is predominant in chymical liquors, as well as whether any of them be ſo or not. For though in our notes upon the tenth and twentieth experiments I have ſhown you a way, by means of the tincture of *Lignum Nephriticum*, or of ſyrup of violets, to diſcover whether a propounded ſalt be acid or not; yet you can thereby only find in general that ſuch and ſuch ſalts belong not to the tribe of acids, but cannot determine whether they belong to the tribe of urinous ſalts, (under which, for diſtinction ſake, I comprehend all thoſe volatile ſalts of animal or other ſubſtances that are contrary to acids) or to that of alcalies. For as well the one as the other of theſe ſalino-ſulphureous ſalts will reſtore the ceruleous colour to the tincture of *Lignum Nephriticum*, and turn that of ſyrup of violets into green. Wherefore this XLth experiment does opportunely ſupply the deficiency of thoſe. For being ſollicitous to find out ſome ready ways of diſcriminating the tribes of chymical ſalts, I found that all thoſe I thought fit to make trial of, would, if they were of a lixiviate nature, make with ſublimate diſſolved in fair water an orange tawny precipitate; whereas if they were of an urinous nature, the precipitate would be white and milky. So that having always by me ſome ſyrup of violets and ſome ſolution of ſublimate, I can by the help of the firſt of thoſe liquors diſcover in a trice, whether the propounded ſalt or ſaline body be of an acid nature or no, if it be, I need (you know) inquire no further; but if it be not, I can very eaſily, and as readily diſtinguiſh between the other two kinds of ſalts, by the white or orange-colour that is immediately produced, by letting fall a few drops or grains of the ſalt to be examined, into a ſpoonful of the clear ſolution of ſublimate. For example, it has been ſuppoſed by ſome eminently learned, that when ſal armoniack being mingled with an alcali is forced from it by the fire in cloſe veſſels, the volatile ſalt that will thereby be obtained (if the operation be ſkilfully performed,) is but a more fine and ſubtile ſort of ſal-armoniack, which, it is preſumed, this operation does but more exquiſitely purify than common ſolutions, filtrations, and coagulations. But this opinion may be eaſily ſhown to be erroneous, as by other arguments, ſo particularly by the lately delivered method of diſtinguiſhing the tribes of ſalts. For the ſaline ſpirit of ſal-armoniack, as it is in many other manifeſt qualities very like the ſpirit of urine, ſo like, that it will in a trice make ſyrup of violets of a lovely green, turn a ſolution of good verdigreaſe into an excellent azure, and make the ſolution of a ſublimate yield a white precipitate; inſomuch that in moſt (for I ſay not all of the experiments) where I aim

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aim only at producing a ſudden change of colour, I ſcruple not to uſe ſpirit of ſal-armoniack when it is at hand, inſtead of ſpirit of urine, as indeed it ſeems chiefly to conſiſt (beſides the phlegm that helps to make it fluid) of the volatile urinous ſalt (yet not excluding that of ſoot) that abounds in the ſal armoniack and is ſet at liberty from the ſea-ſalt wherewith it was formerly aſſociated, and clogged, by the operation of the alcali, that divides the ingredients of ſal armoniack, and retains that ſea-ſalt with it ſelf: What uſe may be made of the like way of exploration in that inquiry which puzzles ſo many modern Naturaliſts, whether the rich pigment (which we have often had occaſion to mention) belongs to the vegetable or animal kingdom, you may find in another place, where I give you ſome account of what I tried about cochineal. But I think it needleſs to exemplify here our method by any other inſtances, many ſuch being to be met with in divers parts of this treatiſe; but I will rather advertiſe you, that by this way of examining chymical liquors, you may not only in moſt caſes conclude affirmatively, but in ſome caſes negatively. As ſince ſpirit of wine, and, as far as I have tried, thoſe chymical oils which artiſts call eſſential, did not (when I uſed them as I had uſed the ſeveral families of ſalts upon that ſyrup) turn ſyrup of violets red or green, nor the ſolution of ſublimate white or yellow; I inferred it may thence be probably argued, that either they are deſtitute of ſalt, or have ſuch as belongs not to either of the three grand families often already mentioned. When I went to examine the ſpirit of oak, or of ſuch like concretes forced over through a retort, I found by this means amongſt others, that (as I elſewhere ſhow) thoſe chymiſts are much miſtaken in it, that account it a ſimple liquor, and one of their hypoſtatical principles. For not to mention what phlegm it may have, I found that with a few drops of one of this ſort of ſpirits mixed with a good proportion of ſyrup of violets, I could change the colour and make it purpliſh, by the affinity of which colour to redneſs, I conjectured that this ſpirit had ſome acid corpuſcles in it; and accordingly I found, that as it would deſtroy the blueneſs of a tincture of *Lignum Nephritieum*, ſo being put upon corals, it would corrode them, as common ſpirit of vinegar, and other acid liquors are wont to do. And farther to examine whether there were not a great part of the liquor that was not of an acid nature, having ſeparated the ſour or vinegar-like part from the reſt, which (if I miſtake not) is far the more copious; we concluded, as we had conjectured, the other or remaining part, though it had a ſtrong taſte as well as ſmell, to be of a nature differing from that of either of the three ſorts of ſalts above-mentioned, ſince it did as little as ſpirit of wine, and chymical oils, alter the colour either of ſyrup of violets or ſolution of ſublimate: whence we alſo inferred, that the change that had been made of that ſyrup into a purple colour, was effected by the vinegar, that was one of the two ingredients of the liquor, which was wont to paſs for a ſimple or uncompounded ſpirit. And, upon this account, it was of the ſpirit of oak (and the like concretes) freed from its vinegar, that I elſewhere told you, that I had not then obſerved it (and I have repeated the trial but very lately) to deſtroy the ceruleous tincture of *Lignum Nephriticum*. But this only *en paſſant*; for the chief thing I had to add was this: That by the ſame way may be examined and diſcovered divers changes that are produced in bodies, either by nature only, or by art; either of them being able, by changing the texture of ſome concretes I could name, to qualify them to operate after a new manner upon the above mentioned ſyrup, or ſolution, or both: And by this means, to tell you that, upon the by, I have been able to diſcover, that there may be made bodies, which though they run *per deliquium*, as readily as ſalt of tartar, belong in other reſpects, not to the family of alcalies, much leſs to that of ſalſuginous or that of acid ſalts. Perhaps too, I may know a way of making a highly operative ſaline body, that ſhall neither change the colour of ſyrup of violets, nor precipitate the ſolution of ſublimate; and I can likewiſe, if I pleaſe, conceal by what liquors I perform ſuch changes of colour, as I have been mentioning to you, by quite altering the texture of ſome ordinary chymical productions, the exploration of which is the main uſe of the fortieth experiment, which I think teaches not a little, if it teach us to diſcover the nature of thoſe things (in reference to ſalt) that are obtained by the ordinary chymical analyſis of mixed bodies, though perhaps there may be other bodies prepared by chymiſtry, which may have the ſame effects in the change of colours, and yet be produced not from what chymiſts call the reſolution of bodies, but from their compoſition. But the diſcourſing of things of this nature is more proper for another place. I ſhall now only add, what might perhaps have been more ſeaſonably told you before; That the reaſon why the way of exploration of ſalts hitherto delivered ſucceeds in the ſolution of ſublimate, depends upon the particular texture of that ſolution, as well as upon the differing natures of the ſaline liquors employed to precipitate it. For gold diſſolved in aqua regia, whether you precipitate it with oil of tartar, which is an alcali, or with ſpirit of urine, or ſal armoniack, which belongs to the family of volatile ſalts, will either way afford a yellow ſubſtance: though with ſuch an acid liquor as, I ſay not ſpirit of ſalt, the body that yields it, being upthe matter an ingredient of aqua regis, but oil of vitriol it ſelf, I did not find that I could precipitate the metal out of the ſolution, or deſtroy the colour of it; though the ſame oil of vitriol would readily precipitate ſilver diſſolved in aqua-fortis. And if you diſſolve pure ſilver in aqua-fortis, nd ſuffer it to ſhoot into cryſtals, the clear ſolution of theſe made in fair water, will afford a very white precipitate, whether it be made with an alcali, or an acid ſpirit, as that of ſalt; whereas, which may ſeem ſomewhat ſtrange, with ſpirit of ſal armoniack (that I uſed was made of quick-lime)

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I could obtain no ſuch white precipitate: that volatile ſpirit, nor (as I remember) that of urine, ſcarce doing any more than ſtriking down a very ſmall quantity of matter, which was neither white nor whitiſh; ſo that the remaining liquor being ſuffered to evaporate till the ſuperfluous moiſture was gone, the greateſt part of the metalline corpuſcles with the ſaline ones that had imbibed them, concoagulated into ſalt, as is uſual in ſuch ſolutions, wherein the metal has not been precipitated.

EXPERIMENT XLI.

OF kin to the laſt or fortieth experiment is another which I remember I have ſometimes ſhewn to Virtuoſi that were pleaſed not to diſlike it. I took ſpirit of urine made by fermentation, and with a due proportion of copper brought into ſmall parts, I obtained a very lovely azure ſolution; and when I ſaw the colour was ſuch as was requiſite, pouring into a clean glaſs about a ſpoonful of this tincted liquor, (of which I uſed to keep a quantity by me) I could, by ſhaking into it ſome drops of ſtrong oil of vitriol, deprive it in a trice of its deep colour, and make it look like common water.

ANNOTATION.

THIS experiment brings into my mind this other, which oftentimes ſucceeds well enough, though not quite ſo well as the former; namely, that if into about a ſmall ſpoonful of a ſolution of good French verdigreaſe made in fair water, I dropt and ſhaked ſome ſtrong ſpirit of ſalt, or rather dephlegmed aqua fortis, the greenneſs of the ſolution would be made in a trice almoſt totally to diſappear, and the liquor held againſt the light would ſcarce ſeem other than clear or limpid, to any but an attentive eye: which is therefore remarkable, becauſe we know that aqua fortis corroding copper, which is it that gives the colour to verdigreaſe, is wont to reduce it to a green blue ſolution. But if into the other altogether or almoſt colourleſs liquor I was ſpeaking of, you drop a juſt quantity either of oil of tartar or ſpirit of urine, you ſhall find that after the ebullition is ceaſed, the mixture will diſcloſe a lively colour, though ſomewhat differing from that which the ſolution of verdigreaſe had at firſt.

EXPERIMENT XLII.

THAT the colour (*Pyrophilus*) of a body may be changed by a liquor which of it ſelf is of no colour, provided it be ſaline, we have already manifeſted by a multitude of inſtances. Nor doth it ſeem ſo ſtrange, becauſe ſaline particles ſwimming up and down in liquors, have been by many obſerved to be very operative in the production and change of colours. But divers of our friends, that are not acquainted with chymical operations, have thought it very ſtrange that a white body, and a dry one too, ſhould immediately acquire a rich new colour upon the bare affuſion of ſpring-water deſtitute as well of adventitious ſalt as of tincture. And yet (*Pyrophilus*) the way of producing ſuch a change of colours may be eaſily enough lighted on, by thoſe that are converſant in the ſolutions of mercury. For we have tried, that though by evaporating a ſolution of quickſilver in aqua fortis, and abſtracting the liquor till the remaining matter began to be well, but not too ſtrongly dried, fair water poured on the remaining calx made it but ſomewhat yellowiſh; yet when we took good quickſilver, and three or four times its weight of oil of vitriol, in caſe we in a glaſs retort placed in ſand drew off the ſaline menſtruum from the metalline liquor, till there remained a dry calx at the bottom, though this precipitate were a ſnow-white body, yet upon pouring on it a large quantity of fair water, we did almoſt in a moment perceive it to paſs from a milky colour to one of the lovelieſt light yellows that ever we had beheld. Nor is the turbith mineral, that chymiſts extol for its power to ſalivate, and for other virtues, of a colour much inferior to this, though it be often made with a differing proportion of the ingredients, a more troubleſome way. For *Beguinus*, who calls it *Mercurius præcipitatus optimus*, takes to one part of quickſilver but two of liquor, and that is rectified oil of ſulphur, which is (in *England* at leaſt) far more ſcarce and dear than oil of vitriol; he alſo requires a previous digeſtion, two or three cohobations, and frequent ablutions with hot diſtilled water; with other preſcriptions, which though they may conduce to the goodneſs of the medicine, which is that he aims at, are troubleſome, and, our trials have informed you, unneceſſary to the obtaining the lemon colour, which he regards not. But though we have very rarely ſeen either in painters ſhops, or elſewhere, a finer yellow than that which we have divers times this way produced, (which is the more conſiderable, becauſe durable and pleaſant yellows are very hard to be met with, as may appear by the great uſe which painters are for its colour's ſake fain to make of that pernicious and heavy mineral, orpiment;) yet I fear our yellow is too coſtly, to be like to be imployed by painters, unleſs about choice pieces of work, nor do I know how well it will agree with every pigment, eſpecially, with oiled colours. And whether this experiment, though it have ſeemed ſomewhat ſtrange to moſt we have ſhewn it to, be really of another nature than thoſe wherein ſaline liquors are employed, may, as we formerly alſo hinted, be ſo plauſibly doubted, that whether the water poured on the calx, do barely by imbibing ſome of its ſaline parts alter its colour, by altering its texture, or whether by diſſolving the concoagulated ſalts, it does become a ſaline menſtruum, and, as ſuch, work upon the mercury, I freely leave to you, *Pyrophilus*, to conſider. And that I may give you ſome aſſiſtance in your inquiry, I will not only tell you, that I have ſeveral times with fair water waſhed from this calx, good ſtore of ſtrongly-taſted corpuſcles, which by the abſtraction of the menſtruum, I could reduce into ſalt; but I will alſo ſubjoin an experiment, which I deviſed,

Beguinus *Tyr. Chy. Lib.* 2. *cap.* 13.

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deviſed, to ſhew among other things, how much a real and permanent colour may be as it were drawn forth by a liquor that has neither colour, nor ſo much as ſaline or other active parts, provided it can but bring the parts of the body it imbibes to convene into cluſters diſpoſed after the manner requiſite to the exhibiting of the emergent colour. The experiment was this.

EXPERIMENT XLIII.

WE took good common vitriol, and having beaten it to powder, and put it into a crucible, we kept it melted in a gentle heat, till by the evaporation of ſome parts, and the ſhuffling of the reſt, it had quite loſt its former colour; what remained we took out, and found it to be a friable calx, of a dirty grey. On this we poured fair water, which it did not colour green or blue, but only ſeemed to make a muddy mixture with it, then ſtopping the phial wherein the ingredients were put, we let it ſtand in a quiet place for ſome days, and after many hours the water having diſſolved a good part of the imperfectly calcined body, the vitriolate corpuſcles ſwimming to and fro in the liquor, had time by their opportune occurſions to conſtitute many little maſſes of vitriol, which gave the water they impregnated a fair vitriolate colour; and this liquor being poured off, the remaining dirty powder did in proceſs of time communicate the like colour, but not ſo deep, to a ſecond parcel of clear water that we poured on it. But this experiment, *Pyrophilus*, is (to give you that hint by the way) of too luciferous a nature to be fit to be fully proſecuted, now that I am in haſte, and willing to diſpatch what remains. And we have already ſaid of it, as much as is requiſite to our preſent purpoſe.

EXPERIMENT XLIV.

IT may (*Pyrophilus*) ſomewhat contribute towards the ſhewing how much ſome colours depend upon the leſs or greater mixture, and (as it were) contemperation of the light with ſhades, to obſerve how that ſometimes the number of particles, of the ſame colour, received into the pores of a liquor, or ſwimming up and down in it, do ſeem much to vary the colour of it. I could here preſent you with particular inſtances to ſhow, how in many (if not moſt) conſiſtent bodies, if the colour be not a light one, as white, yellow, or the like, the cloſeneſs of parts in the pigments makes it look blackiſh, though when it is diſplayed and laid on thinly, it will perhaps appear to be either blue, or green, or red. But the colours of conſiſtent pigments, not being thoſe which the preamble of this experiment has led you to expect examples in, I ſhall take the inſtances I am now to give you, rather from liquors than dry bodies. If then you put a little fair water into a clear and ſlender phial, (or rather into one of thoſe pipes of glaſs, which we ſhall by and by mention;) and let fall into it a few drops of a ſtrong decoction or infuſion of cochineal, or (for want of that) of brazil; you may ſee the tincted drops deſcend like little clouds into the liquor; through which, if, by ſhaking the phial, you diffuſe them, they will turn the water either of a pink colour, or like that which is wont to be made by the waſhing of raw fleſh in fair water; by dropping a little more of the decoction, you may heighten the colour into a fine red, almoſt like that which ennobles rubies; by continuing the affuſion, you may bring the liquor to a kind of a crimſon, and afterwards to a dark and opacous redneſs, ſomewhat like that of clotted blood. And in the paſſage of the liquor from one of theſe colours to the other, you may obſerve, if you conſider it attentively, divers other leſs noted colours belonging to red, to which it is not eaſy to give names; eſpecially conſidering how much the proportion of the decoction to the fair water, and the ſtrength of that decoction, together with that of the trajected light and other circumſtances, may vary the phænomena of this experiment. For the convenienter making whereof, we uſe, inſtead of a phial, any ſlender pipe of glaſs of about a foot or more in length, and about the thickneſs of a man's litttle finger; for, if leaving one end of this pipe open, you ſeal up the other hermetically, (or at leaſt ſtop it exquiſitely with a cork well fitted to it, and overlaid with hard ſealing wax melted, and rubbed upon it;) you ſhall have a glaſs, wherein may be obſerved the variations of the colours of liquors much better than in large phials, and wherein experiments of this nature may be well made with very ſmall quantities of liquor. And if you pleaſe, you may in this pipe produce variety of colours in the various parts of the liquor, and keep them ſwimming upon one another unmixed for a good while. And ſome have marvelled to ſee, what variety of colours we have ſometimes (but I confeſs rather by chance than ſkill) produced in thoſe glaſſes, by the bare infuſion of brazil, variouſly diluted with fair water, and altered by the infuſion of ſeveral chymical ſpirits and other ſaline liquors devoid themſelves of colour: and when the whole liquor is reduced to an uniform degree of colour, I have taken pleaſure to make that very liquor ſeem to be of colours gradually differing, by filling with it glaſſes of a conical figure, (whether the glaſs have its baſis in the ordinary poſition, or turned upwards.) And yet you need not glaſſes of an extraordinary ſhape, to ſee an inſtance of what the various mixture of light and ſhadow can do in the diverſifying of the colour. For if you take but a large round phial, with a ſomewhat long and ſlender neck, and filling it with our red infuſion of brazil, hold it againſt the light, you will diſcern a notable diſparity betwixt the colour of that part of the liquor which is in the body of the phial, and that which is more pervious to the light in the neck. Nay, I remember, that I once had a glaſs and a blue liquor (conſiſting chiefly, or only, if my memory deceive me not, of a certain ſolution of verdigreaſe) ſo fitted for my purpoſe, that though in other glaſſes the experiment would

not ſucceed, yet when that particular glaſs was filled with that ſolution, in the body of the phial it appeared of a lovely blue, and in the neck, (where the light did more dilute the colour,) of a manifeſt green; and though I ſuſpected there might be ſome latent yellowneſs in the ſubſtance of the neck of the glaſs, which might with the blue compoſe that green, yet was I not ſatisfied my ſelf with my conjecture, but the thing ſeemed odd to me, as well as to divers curious perſons to whom it was ſhown. And I lately had a broad piece of glaſs, which being looked on againſt the light ſeemed clear enough, and held from the light appeared very lightly diſcoloured; and yet it was a piece knocked off from a great lump of glaſs, to which if we rejoined it, where it had been broken off, the whole maſs was as green as graſs. And I have ſeveral times uſed bottles and ſtopples that were both made (as thoſe, I had them from, aſſured me) of the very ſame metal; and yet whilſt the bottle appeared but inclining towards a green, the ſtopple (by reaſon of its great thickneſs) was of ſo deep a colour, that you would hardly believe they could poſſibly be made of the ſame materials. But to ſatisfy ſome ingenious men, on another occaſion, I provided my ſelf of a flat glaſs, (which I yet have by me) with which if I look againſt the light with the broad ſide obverted to the eye, it appears like a good ordinary window-glaſs; but if I turn the edge of it to my eye, and place my eye in a convenient poſture in reference to the light, it may contend for deepneſs of colour with an emerald. And this greenneſs puts me in mind of a certain thickiſh, but not conſiſtent pigment I have ſometimes made, and can ſhow you when you pleaſe, which being dropped on a piece of white paper appears, where any quantity of it is fallen, of a ſomewhat crimſon colour; but being with one's finger ſpread thinly on the paper, does preſently exhibit a fair green: which ſeems to proceed only from its diſcloſing its colour upon the extenuation of its depth into ſuperficies, if the change be not ſomewhat helped by the colours degenerating upon one or other of the accounts formerly mentioned. Let me add, that having made divers trials with that blue ſubſtance, which in painters ſhops is called *Litmaſe*, we have ſometimes taken pleaſure to obſerve, that being diſſolved in a due proportion of fair water, the ſolution either oppoſed to the light, or dropped upon white paper, did appear of a deep colour betwixt crimſon and purple; and yet that being ſpread very thin on the paper, and ſuffered to dry on there, the paper was wont to appear ſtained of a fine blue. And to ſatisfy my ſelf, that the diverſity came not from the paper, which one might ſuſpect capable of imbibing the liquor, and altering the colour, I made the trial upon a flat piece of purely white glazed earth, (which I ſometimes make uſe of about experiments of colours) with an event not unlike the former.

AND now I ſpeak of litmaſe, I will add, that having this very day taken a piece of it, that I had kept by me theſe ſeveral years, to make trials about colours, and having let fall a few drops of the ſtrong infuſion of it in fair water, into a fine cryſtal glaſs, ſhaped like an inverted cone, and almoſt full of fair water, I had now (as formerly) the pleaſure to ſee, and to ſhew others, how theſe few tincted drops variouſly diſperſing themſelves through the limpid water, exhibited divers colours, or varieties of purple and crimſon. And when the corpuſcles of the pigment ſeemed to have equally diffuſed themſelves through the whole liquor, I then by putting two or three drops of ſpirit of ſalt, firſt made an odd change in the colour of the liquor, as well as a viſible commotion among its ſmall parts, and in a ſhort time changed it wholly into a very glorious yellow, like that of a topaz. After which if I let fall a few drops of the ſtrong and heavy ſolution of pot-aſhes, whoſe weight would quickly carry it to the ſharp bottom of the glaſs, there would ſoon appear four very pleaſant and diſtinct colours; namely, a bright, but dilute colour at the picked bottom of the glaſs; a purple, a little higher; a deep and glorious crimſon, (which crimſon ſeemed to terminate the operation of the ſalt upward) in the confines betwixt the purple and the yellow; and an excellent yellow, the ſame that before ennobled the whole liquor, reaching from thence to the top of the glaſs. And if I pleaſed to pour very gently a little ſpirit of ſal-armoniack upon the upper part of this yellow, there would alſo be a purple or a crimſon, or both generated there, ſo that the unaltered part of the yellow liquor appeared intercepted betwixt the two neighbouring colours.

MY ſcope in this third experiment (*Pyrophilus*) is manifold, as firſt to invite you to be wary in judging of the colour of liquors in ſuch glaſſes as are therein recommended to you, and conſequently as much, if not more, when you employ other glaſſes. Secondly, that you may not think it ſtrange, that I often content my ſelf to rub upon a piece of white paper the juice of bodies I would examine; ſince not only I could not eaſily procure a ſufficient quantity of the juices of divers of them, but in ſeveral caſes the trials of the quantities of ſuch juices in glaſſes would make us more liable to miſtakes, than the way that in thoſe caſes I have made uſe of. Thirdly, I hope you will by theſe and divers other particulars delivered in this treatiſe, be eaſily induced to think that I may have ſet down many phænomena very faithfully, and juſt as they appeared to me, and yet by reaſon of ſome unheeded circumſtance in the conditions of the matter, and in the degree of light, or the manner of trying the experiment, you may find ſome things to vary from the relations I make of them. Laſtly, I deſigned to give you an opportunity to free your ſelf from the amazement which poſſeſſes moſt men, at the tricks of thoſe mountebanks that are commonly called water-drinkers. For though not only the vulgar, but even many perſons that are far above that rank, have ſo much admired to ſee a man, after having drunk a great deal of fair water, to ſpurt it out again in the form of claret-wine, ſack, and milk, that they have ſuſpected the intervening of magick,

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gick, or ſome forbidden means to effect what they conceived above the power of art; yet having once by chance had occaſion to oblige a wanderer that made profeſſion of that and other juggling tricks, I was eaſily confirmed by his ingenuous confeſſion to me, that this ſo much admired art, indeed conſiſted rather in a few tricks, than in any great ſkill, in altering the nature and colours of things. And I am eaſy to be perſuaded, that there may be a great deal of truth in a little pamphlet printed divers years ago in Engliſh, wherein the author undertakes to diſcover, and that (if I miſtake not) by the confeſſion of ſome of the accomplices themſelves, that a famous water-drinker, then much admired in *England*, performed his pretended tranſmutations of liquors by the help of two or three inconſiderable preparations and mixtures of not unobvious liquors, and chiefly of an infuſion of brazil variouſly diluted and made pale or yellowiſh (and otherwiſe altered) with vinegar; the reſt of their work being performed by the ſhape of the glaſſes, by craft and legerdemain. And for my part, that which I marvel at in this buſineſs, is the drinkers being able to take down ſo much water, and ſpout it out with that violence; though cuſtom and a vomit ſeaſonably taken before hand, may in ſome of them much facilitate the work. But as for the changes made in the liquors, they were but few and ſlight in compariſon of thoſe, that the being converſant in chymical experiments, and dextrous in applying them to the tranſmuting of colours, may eaſily enough enable a man to make, as even what has been newly delivered in this, and the foregoing experiment; eſpecially if we add to it the things contained in the twentieth, the thirty-ninth, and the fortieth experiments, may perhaps have already perſuaded you.

EXPERIMENT XLV.

YOU may, I preſume, *(Pyrophilus)* have taken notice, that in this whole treatiſe I purpoſely decline (as far as I well can) the mentioning of elaborate chymical experiments, for fear of frighting you by their tedioufneſs and difficulty; but yet, in confirmation of what I have been newly telling you about the poſſibility of varying the colours of liquors, better than the water-drinkers are wont to do, I ſhall add, that *Helmont* uſed to make a preparation of ſteel, which a very ingenious chymiſt, his ſon's friend, whom you know, ſometimes employs for a ſuccedaneum to the Spaw-waters, by diluting this *eſſentia martis liquida* (as he calls it) with a due proportion of water. Now that for which I mention to you this preparation (which as he communicated to me, I know he will not refuſe to *Pyrophilus*) is this, that though the liquor (as I can ſhew you when you pleaſe) be almoſt of the colour of a German (not an Oriental) amethiſt, and conſequently remote enough from green, yet a very few drops being let fall into a large proportion of good Rheniſh, or (in want of that) white-wine, (which yet does not quite ſo well) immediately turned the liquor into a lovely green, as I have not without delight ſhown ſeveral curious perſons. By which phænomenon you may learn, among other things, how requiſite it is in experiments about the changes of colours heedfully to mind the circumſtances of them: for water will not, as I have purpoſely tried, concur to the production of any ſuch green, nor did it give that colour to moderate ſpirit of wine, wherein I purpoſely diſſolved it, and wine it ſelf is a liquor that few would ſuſpect of being able to work ſuddenly any ſuch change in a metalline preparation of this nature. And to ſatisfy my ſelf that this new colour proceeds rather from the peculiar texture of the wine, than from any greater acidity, that Rheniſh or white-wine (for that may not abſurdly be ſuſpected) has in compariſon of water; I purpoſely ſharpened the ſolution of this eſſence in fair water, with a good quantity of ſpirit of ſalt, notwithſtanding which, the mixture acquired no greenneſs. And to vary the experiment a little, I tried, that if into a glaſs of Rheniſh wine made green by this eſſence, I dropped an alcalizate ſolution, or urinous ſpirit, the wine would preſently grow turbid, and of an odd dirty colour: but if inſtead of diſſolving the eſſence in wine, I diſſolved it in fair water, ſharpened perhaps with a little ſpirit of ſalt, then either the urinous ſpirit of ſal armoniack, or the ſolution of the fixed ſalt of pot-aſhes, would immediately turn it of a yellowiſh colour, the fixed or urinous ſalt precipitating the vitriolate ſubſtance contained in the eſſence. But here I muſt not forget to take notice of a circumſtance that deſerves to be compared with ſome part of the foregoing experiment; for whereas our eſſence imparts a greenneſs to wine, but not to water, the induſtrious *Olaus Wormius* in his late *Muſæum* tells us of a rare kind of turnſol, which he calls *Bezetta Rubra*, given him by an apothecary that knew not how it was made, whoſe lovely redneſs would be eaſily communicated to water, if it were immerſed in it; but ſcarce to wine, and not at all to ſpirit of wine: in which laſt circumſtance it agrees with what I lately told you of our eſſence, notwithſtanding their diſagreement in other particulars.

Libr. 2. *Cap.* 34.

EXPERIMENT XLVI.

WE have often taken notice, as of a remarkable thing, that metals, as they appear to the eye, before they come to be farther altered by other bodies, do exhibit colours very different from thoſe which the fire and the menſtruum, either apart, or both together, do produce in them; eſpecially conſidering that theſe metalline bodies are after all theſe diſguiſes reducible not only to their former metalline conſiſtence, and other more radical properties, but to their colour too; as if nature had given divers metals to each of them a double colour, an external, and an internal. But though upon a more attentive conſideration of this difference of colours, it ſeemed probable to me that divers (for I ſay not all) of thoſe colours which we have juſt now called internal, are rather produced by the coalition of metalline

metalline particles with thoſe of the ſalts, or other bodies employed to work on them, than by the bare alteration of the parts of the metals themſelves; and though therefore we may call the obvious colours natural or common, and the others adventitious: yet becauſe ſuch changes of colours, from whatſoever cauſe they be reſolved to proceed, may be properly enough taken in to illuſtrate our preſent ſubject, we ſhall not ſcruple to take notice of ſome of them, eſpecially becauſe there are among them ſuch as are produced without the intervention of ſaline menſtruums. Of the adventitious colours of metalline bodies the chief ſorts ſeem to be theſe three: The firſt, ſuch colours as are produced without other additaments by the action of the fire upon metals. The next, ſuch as emerge from the coalition of metalline particles with thoſe of ſome menſtruum employed to corrode a metal or precipitate it; and the laſt, the colours afforded by metalline bodies either colliquated with, or otherwiſe penetrating into, other bodies, eſpecially fuſible ones. But theſe (*Pyrophilus*) are only, as I told you, the chief ſorts of the adventitious colours of metals, for there may others belong to them, of which I ſhall hereafter have occaſion to take notice of ſome, and of which alſo there poſſibly may be others that I never took notice of.

AND to begin with the firſt ſort of colours, it is well enough known to chymiſts, that tin being calcined by fire alone is wont to afford a white calx, and lead calcined by fire alone affords that moſt common red powder we call minium: copper alſo calcined *per ſe*, by a long or violent fire, is wont to yield (as far as I have had occaſion to take notice of it) a very dark or blackiſh powder; that iron likewiſe may by the action of reverberated flames be turned into a colour almoſt like that of ſaffron, may be eaſily deduced from the preparation of that powder, which by reaſon of its colour and of the metal it is made of, is by chymiſts called *Crocus Martis per ſe*. And that mercury, made by the ſtreſs of fire, may be turned into a red powder, which chymiſts call precipitate *per ſe*, I elſewhere more particularly declare.

ANNOTATION I.

IT is not unworthy the admoniſhing you, (*Pyrophilus*) and it agrees very well with our conjectures about the dependence of the change of a body's colour upon that of its texture, that the ſame metal may by the ſucceſſive operation of the fire receive divers adventitious colours, as is evident in lead, which before it come to ſo deep a colour as that of minium, may paſs through divers others.

ANNOTATION II.

NOT only the calces, but the glaſſes of metals, vitrified *per ſe*, may be of colours differing from the natural or obvious colour of the metal; as I have obſerved in the glaſs of lead, made by long expoſing crude lead to a violent fire, and what I have obſerved about the glaſs or ſlag of copper (of which I can ſhow you ſome of an odd kind of texture) may be elſewhere more conveniently related. I have likewiſe ſeen a piece of very dark glaſs, which an ingenious artificer that ſhowed it me profeſſed himſelf to have made of ſilver alone by an extreme violence (which ſeems to be no more than is needful) of the fire.

ANNOTATION III.

MINERALS alſo by the action of the fire may be brought to afford colours very differing from their own, as I not long ſince noted to you about the variouſly coloured flowers of antimony; to which we may add the whitiſh grey-colour of its calx, and the yellow or reddiſh colour of the glaſs, whereinto that calx may be fluxed.

AND I remember, that I elſewhere told you, that vitriol calcined with a very gentle heat, and afterwards with higher and higher degrees of it, may be made to paſs through ſeveral colours before it deſcends to a dark purpliſh colour, whereto a ſtrong fire is wont at length to reduce it. But to inſiſt on the colours produced by the operation of fire upon ſeveral minerals, would take up far more time than I have now to ſpare.

EXPERIMENT XLVII.

THE adventitious colours produced upon metals, or rather with them, by ſaline liquors, are many of them ſo well known to chymiſts, that I would not here mention them, but that beſides a not un-needed teſtimony, I can add ſomething of my own, to what I ſhall repeat about them; and divers experiments which are familiar to chymiſts, are as yet unknown to the greateſt part of ingenious men.

THAT gold diſſolved in aqua-regia ennobles the menſtruum with its own colour, is a thing that you cannot (*Pyrophilus*) but have often ſeen. The ſolutions of mercury in aqua-fortis are not generally taken notice of, to give any notable tincture to the menſtruum; but ſometimes when the liquor firſt falls upon the quick-ſilver, I have obſerved a very remarkable, though not durable greenneſs, or blueneſs to be produced; which is a phænomenon not unfit for you to conſider, though I have not now the leiſure to diſcourſe upon it. Tin corroded by aqua-fortis till the menſtruum will work no farther on it, becomes exceeding white; but, as we elſewhere note, does very eaſily of itſelf acquire the conſiſtence, not of a metalline calx, but of a coagulated matter, which we have obſerved with pleaſure to look ſo like, either to curdled milk, or curdled whites of eggs, that a perſon unacquainted with ſuch ſolutions may eaſily be miſtaken in it. But when I purpoſely prepared a menſtruum that would diſſolve it as aqua-fortis diſſolves ſilver, and not barely corrode it, and quickly let it fall again, I remember not that I took notice of any particular colour in the ſolution, as if the more whitiſh metals did not much tinge their menſtruums, though the conſpicuouſly coloured metals as gold, and copper, do. For lead diſſolved in ſpirit of vinegar or aqua-fortis gives a ſolution clear enough, and if the menſtruum

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ſtruum be abſtracted appears either diaphanous or white. Of the colour of iron we have elſewhere ſaid ſomething: and it is worth noting, that though if that metal be diſſolved in oil of vitriol diluted with water, it affords a ſalt or magiſtery ſo like in colour, as well as ſome other qualities, to other green vitriol, that chymiſts do not improperly call it *Vitriolum Martis*; yet I have purpoſely tried, that, by changing the menſtruum, and pouring upon the filings of ſteel, inſtead of oil of vitriol, aqua fortis, (whereof, as I remember, I uſed four parts to one of the metal) I obtained not a green, but a ſaffron colour ſolution; or rather a thick liquor of a deep but yellowiſh red. Common ſilver, ſuch as is to be met with in coins, being diſſolved in aqua fortis, yields a ſolution tincted like that of copper, which is not to be wondered at, beeauſe in the coining of ſilver, they are wont (as we elſewhere particularly inform you) to give it an allay of copper, and that, which is ſold in ſhops for refined ſilver, is not (ſo far as we have tried) ſo perfectly free from that ignobler metal, but that a ſolution of it in aqua fortis will give a venereal tincture to the menſtruum. But we could not obſerve upon the ſolution of ſome ſilver, which was perfectly refined, (ſuch as ſome that we have, from which eight or ten times its weight of lead has been blown off) that the menſtruum, though held againſt the light in a cryſtal phial, did manifeſtly diſcloſe any tincture, only it ſeemed ſometimes not to be quite deſtitute of a little, but very faint blueiſhneſs.

But here I muſt take notice, that of all the metals, there is not any, which doth ſo eaſily and conſtantly diſcloſe its unobvious colour, as copper doth. For not only in acid menſtruums, as aqua fortis and ſpirit of vinegar, it gives a blueiſh green ſolution, but if it be almoſt any way corroded, it appears of one of thoſe two colours, as may be obſerved in verdigreaſe made ſeveral ways, in that odd preparation of Venus, which we elſewhere teach you to make with ſublimate, and in the common vitriols of Venus delivered by chymiſts. And ſo conſtant is the diſpoſition of copper, notwithſtanding the diſguiſe artiſts put upon it, to diſcloſe the colour we have been mentioning, that we have by forcing it up with ſal-armoniack obtained a ſublimate of a blueiſh colour. Nay, a famous Spagyriſt affirms, that the very mercury of it is green; but till he teach us an intelligible way of making ſuch a mercury, we muſt content ourſelves to inform you, that we have had a cupreous body, that was precipitated out of a diſtilled liquor, that ſeemed to be the ſulphur of Venus, and ſeemed, even when flaming, of a greeniſh colour. And indeed copper is a metal ſo eaſily wrought upon by liquors of ſeveral kinds, that I ſhould tell you, I know not any mineral, that will concur to the production of ſuch a variety of colours as copper diſſolved in ſeveral menſtruums, as ſpirit of vinegar, aqua fortis, aqua regis, ſpirit of nitre, of urine, of ſoot, oils of ſeveral kinds, and I know not how many other liquors, if the variety of ſomewhat differing colours (that copper will be made to aſſume, as it is wrought upon by ſeveral liquors) were not comprehended within the limits of greeniſh blue, or bluiſh green.

And yet I muſt adverti ſe you (*Pyrophilus*) that being deſirous to try, if I could not make with crude copper a green ſolution without the blueiſhneſs, that is wont to accompany its vulgar ſolutions, I bethought my ſelf of uſing two menſtruums, which I had not known employed to work on this metal, and which I had certain reaſons to make trial of, as I ſucceſsfully did. The one of theſe liquors (if I much miſremember not) was ſpirit of ſugar diſtilled in a retort, which muſt be warily done, (if you will avoid breaking your glaſſes;) and the other oil or ſpirit of turpentine, which affords a fine green ſolution, that is uſeful to me on ſeveral occaſions. And yet to ſhew, that the adventitious colour may reſult, as well from the true and permanent copper it ſelf, as the ſalts wherewith it is corroded, I ſhall add, that if you take a piece of good *Dantzick* copperas, or any other vitriol, wherein Venus is predominant, and having moiſtened it in your mouth, or with fair water, rub it upon a whetted knife, or any other bright piece of ſteel or iron, it will (as we have have formerly told you) preſently ſtain the ſteel with a reddiſh colour, like that of copper; the reaſon of which we muſt not now ſtay to inquire.

ANNOTATION I.

I Presume you may have taken notice (*Pyrophilus*) that I have borrowed ſome of the inſtances mentioned in this 47th experiment from the laboratories of chymiſts; and becauſe in ſome (though very few) other paſſages of this eſſay, I have likewiſe made uſe of experiments mentioned alſo by ſome ſpagyrical writers, I think it not amiſs to repreſent to you on this occaſion once for all ſome things, beſides thoſe which I intimated in the preamble of this preſent experiment. For beſides, that it is very allowable for a writer to repeat an experiment, which he invented not, in caſe he improve it; and beſides that many experiments familiar to chymiſts are unknown to the generality of learned men, who either never read chymical proceſſes, or never underſtood their meaning, or never durſt believe them; beſides theſe things, I ſay, I ſhall repreſent, that, as to the few experiments I have borrowed from the chymiſts, if they be very vulgar, it would perhaps be difficult to aſcribe each of them its own author, and it is more than the generality of chymiſts themſelves can do: and if they be not of very known and familiar practice among them, unleſs the authors, wherein I found them, had given me cauſe to believe themſelves had tried them, I know not why I might not ſet them down, as a part of the phænomena of colours, which I preſent you; many things unanimouſly enough delivered as matters of fact by I know not how many chymical writers, being not to be relied on, upon the ſingle authority of ſuch authors: for inſtance, as ſome Spagyriſts deliver

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(perhaps amongſt ſeveral deceitful proceſſes) that *ſaccharum Saturni* with ſpirit of turpentine will afford a balſam, ſo *Beguinus* and many more tell us, that the ſame concrete (*ſaccharum Saturni*) will yield an incomparably fragrant ſpirit, and a pretty quantity of two ſeveral oils. And yet ſince many have complained, as well as I have done, that they could find no ſuch odoriferous, but rather an ill-ſcented liquor, and ſcarce any oil in their diſtillation of that ſweet vitriol, a wary perſon would as little build any thing on what they ſay of the former experiment, as upon what they aver of the latter; and therefore I ſcrupled not to mention this red balſam, of which I have not ſeen any, (but what I made) among my other experiments about redneſs.

ANNOTATION II.

WE have ſometimes had the curioſity to try, what colours minerals, as tin-glaſs, antimony, ſpelter, *&c.* would yield in ſeveral menſtruums; nor have we forborn to try the colours of ſtones, of which that famous one, (which *Helmont* calls *Paracelſus*'s *Ludus*) though it be digged out of the earth, and ſeem a true ſtone, has afforded in menſtruums capable to diſſolve ſo ſolid a ſtone, ſometimes a yellowiſh, ſometimes a red ſolution, of both which I can ſhew you. But though I have from minerals obtained with ſeveral menſtruums very differing colours, and ſome ſuch as, perhaps, you would be ſurprized to ſee drawn from ſuch bodies; yet I muſt now paſs by the particulars, being deſirous to put an end to this treatiſe, before I put an end to your patience and my own.

ANNOTATION III.

AND yet before I paſs to the next experiment, I muſt put you in mind, that the colours of metals may in many caſes be further altered by employing, either precipitating ſalts, or other convenient ſubſtances to act upon their ſolutions. Of this you may remember that I have given you ſeveral inſtances already, to which may be added ſuch as theſe; that if quickſilver be diſſolved in aqua fortis, and precipitated out of the ſolution, either with water impregnated with ſea-ſalt, or with the ſpirit of the concrete, it falls to the bottom in the form of a white powder; whereas if it be precipitated with an alcali, it will afford a yellowiſh or tawny powder; and if there be no precipitation made, and the menſtruum be drawn off with a convenient fire, the corroded mercury will remain in the bottom, in the form of a ſubſtance, that may be made to appear of differing colours by differing degrees of heat: As I remember, that lately having purpoſely abſtracted aqua fortis from ſome quickſilver, that we had diſſolved in it, ſo that there remained a white calx, expoſing that to ſeveral degrees of fire, and afterwards to a naked one, we obtained ſome new colours, and at length the greateſt part of the calx lying at the bottom of the phial, and being brought partly to a deep yellow, and partly to a red colour, the reſt appeared elevated to the upper part and neck of the phial, ſome in the form of reddiſh, and ſome of an aſh-colour ſublimate. But of the differing colours, which by differing ways and working of quickſilver with fire, and ſaline bodies, may be produced in precipitates, I may elſewhere have occaſion to take further notice. I alſo told you not long ſince, that if you corrode quickſilver with oil of vitriol inſtead of aqua fortis, and abſtract the menſtruum, there will remain a white calx, which by the affuſion of fair water preſently turns into a lemon colour. And even the ſuccedaneum to a menſtruum may ſometimes ſerve the turn, to change the colours of a metal. The lovely red, which painters call vermilion, is made of mercury, which is of the colour of ſilver; and of brimſtone, which is of kin to that of gold, ſublimed up together in a certain proportion, as is vulgarly known to Spagyriſts.

EXPERIMENT XLVIII.

THE third chief ſort of the adventitious colours of metals is that, which is produced by aſſociating them (eſpecially when calcined) with other fuſible bodies, and principally *Venice*, and other fine glaſs, devoid of colour.

I HAVE formerly given you an example, whereby it may appear, that a metal may impart to glaſs a colour much differing from its own, when I told you how with ſilver I had given glaſs a lovely golden colour. And I ſhall now add, that I have learned from one of the chief artificers, that ſells painted glaſs, that thoſe of his trade colour it yellow with a preparation of the calx of ſilver. Though having lately had occaſion among other trials to mingle a few grains of ſhell-ſilver (ſuch as is employed with the pencil and pen) with a convenient proportion of powdered cryſtal glaſs, having kept them two or three hours in fuſion, I was ſurprized to find the colliquated maſs to appear, upon breaking the crucible, of a lovely ſaphirine blue; which made me ſuſpect my ſervant might have brought me a wrong crucible: but he conſtantly affirmed it to be the ſame, wherein the ſilver was put, and conſiderable circumſtances countenanced his aſſertion, ſo that till I have opportunity to make farther trial, I cannot but ſuſpect, either that ſilver, which is not (which is not very probable) brought to a perfect fuſion and colliquation with glaſs, may impart to it other colours than when nealed upon it; or elſe (which is leſs unlikely) that though ſilver-beaters uſually chuſe the fineſt coin they can get, as that which is moſt extenſive under the hammer, yet the ſilver leaves, of which this ſhell-ſilver was made, might retain ſo much copper, as to enable it to give the predominant tincture to the glaſs.

FOR, I muſt proceed to tell you (*Pyrophilus*) as another inſtance of the adventitious colours of metals, that, which is ſomething ſtrange, namely, that, though copper calcined *per ſe* affords but a dark and baſely coloured calx, yet the glaſs-men do with it, as themſelves inform me, tinge their glaſs green. And I remember, that when once we took ſome crude copper, and by frequent ignition quenching it in water

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water had reduced it to a dark and ill-coloured powder, and afterwards kept it in fuſion in about a hundred times its weight of fine glaſs, we had, though not a green, yet a blue coloured maſs; which would perhaps have been green, if we had hit right upon the proportion of the materials, and the degree of fire, and the time wherein it ought to be kept in fuſion; ſo plentifully does that metal abound in a venereal tincture, as artiſts call it, and in ſo many ways does it diſcloſe that richneſs. But though copper do, as we have ſaid, give ſomewhat near the like colour to glaſs, which it does to aqua fortis, yet it ſeems worthy to enquire, whether theſe new colours, which mineral bodies diſcloſe in melted glaſs, proceed from the coalition of the corpuſcles of the mineral with the particles of the glaſs as ſuch, or from the action (excited or actuated by fire) of the alcalizate ſalt (which is a main ingredient of glaſs) upon the mineral body, or from the concurrence of both theſe cauſes, or elſe from any other. But to return to that which we were ſaying, we may obſerve, that putty made by calcining together a proportion of tin and lead, as it is it ſelf a white calx, ſo does it turn the *pitta di cryſtallo* (as the glaſs-men call the matter of the purer ſort of glaſs, wherewith it is colliquated) into a white maſs; which, if it be opacous enough, is employed, as we elſewhere declare, for white amel. But of the colours, which the other metals may be made to produce in colourleſs glaſs, and other vitrifiable bodies, that have native colours of their own, I muſt leave you to inform your ſelf upon trial; or at leaſt muſt forbear to do it till another time, conſidering how many annotations are to follow, upon what has in this and the two former experiments been ſaid already.

ANNOTATION I.

WHEN the materials of glaſs being melted with calcined tin, have compoſed a maſs undiaphanous and white, this white amel is as it were the baſis of all thoſe fine concretes, that goldſmiths and ſeveral artificers employ in the curious art of enamelling. For this white and fuſible ſubſtance will receive into it ſelf, without ſpoiling them, the colours of divers other mineral ſubſtances, which like it will endure the fire.

ANNOTATION II.

SO that as by the preſent (XLVIII) experiment it appears, that divers minerals will impart to fuſible maſſes colours differing from their own; ſo by the making and compounding of amels, it may appear, that divers bodies will both retain their colour in the fire, and impart the ſame to ſome others wherewith they were vitrified, and in ſuch trials as that mentioned in the ſeventeenth experiment, where I told you, that even in amels a blue and yellow will compound a green. It is pretty to behold, not only that ſome colours are of ſo fixed a nature, as to be capable of mixture without receiving any detriment by the fire, that does ſo eaſily deſtroy or ſpoil thoſe of other bodies; but mineral pigments may be mingled by fire little leſs regularly and ſucceſsfully, than in ordinary dying fatts, the vulgar colours are wont to be mingled by the help of water.

ANNOTATION III.

IT is not only metalline, but other mineral bodies, that may be employed, to give tinctures unto glaſs; and it is worth noting how ſmall a quantity of ſome mineral ſubſtances will tinge a comparatively vaſt proportion of glaſs; and we have ſometimes attempted to colour glaſs, even with precious ſtones, and had cauſe to think the experiment not caſt away. And it is known by them, that have looked into the art of glaſs, that the artificers uſed to tinge their glaſs blue with that dark mineral zaffora (ſome of my trials on which I elſewhere acquaint you) which ſome would have to be a mineral earth, others a ſtone, and others neither the one nor the other, but which is confeſſedly of a dark, but not a blue colour, though it be not agreed of what particular colour it is. It is likewiſe though a familiar yet a remarkable practice among thoſe, that deal in the making of glaſs, to employ (as ſome of themſelves have informed me) what they call manganeſs, and ſome authors call *Magneſia* (of which I make particular mention in another treatiſe) to exhibit in glaſs not only other colours than its own, (which is ſo like in darkneſs or blackiſhneſs to the loadſtone, that is given by mineraliſts for one of the reaſons of its Latin name) but colours differing from one another. For though they uſe it, (which is ſomewhat ſtrange) to clarify their glaſs, and free it from that blueiſh greeniſh colour, which elſe it would too often be ſubject to; yet they alſo employ it in certain proportions, to tinge their glaſs both with red colour, and with a purpliſh or murry; and putting in a greater quantity, they alſo make with it that deep-obſcure glaſs, which is wont to paſs for black, which agrees very well with, and may ſerve to confirm what we noted near the beginning of the 44th experiment, of the ſeeming blackneſs of thoſe bodies, that are over-charged with the corpuſcles of ſuch colours, as red, or blue, or green, *&c.* And as by ſeveral metals and other minerals we can give various colours to glaſs, ſo on the other ſide, by the differing colours, that mineral ores, or other mineral powders, being melted with glaſs, diſcloſe in it, a good conjecture may be oftentimes made of the metal or known mineral, that the ore propoſed either holds, or is moſt of kin to. And this eaſy way of examining ores may be in ſome caſes of good uſe, and is not ill delivered by *Glauber*, to whom I ſhall at preſent refer you for a more particular account of it; unleſs your curioſity command alſo what I have obſerved about theſe matters. Only I muſt here advertiſe you that great circumſpection is requiſite to keep this way from proving fallacious, upon the account of the variations of colour, that may be produced by the differing proportions, that may be uſed betwixt the ore and the glaſs, by the richneſs or poorneſs of the

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the ore it ſelf, by the degree of fire, and eſpecially by the length of time, during which the matter is kept in fuſion; as you will eaſily gather from what you will quickly meet with in the following annotation upon this 48th experiment.

ANNOTATION IV.

THERE is another way, and differing enough from thoſe already mentioned, by which metals may be brought to exhibit adventitious colours: for by this, the metal does not ſo much impart a colour to another body, as receive a colour from it, or rather both bodies do by the new texture reſulting from their miſtion produce a new colour. I will not inſiſt to this purpoſe upon the examples afforded us by yellow orpiment, and common ſea-ſalt, from which, ſublimed together, chymiſts unanimouſly affirm their white or cryſtalline arſenick to be made: but it is not unworthy our noting, that though yellow orpiment be acknowledged to be the copiouſeſt by far of the two ingredients of arſenick, yet this laſt named body being duly added to the higheſt coloured metal copper, when it is in fuſion, gives it whiteneſs both within and without. Thus *Lapis Calaminaris* changes and improves the colour of copper, by turning it into braſs. And I have ſometimes, by the help of zink duly mixed after a certain manner, given copper one of the richeſt golden colours, that ever I have ſeen the beſt true gold ennobled with. But pray have a care, that ſuch hints fall not into any hands, that may miſ-employ them.

ANNOTATION V.

UPON the knowledge of the differing ways of making minerals and metals produce their adventitious colours in bodies capable of vitrification, depends the pretty art of making what chymiſts by a barbarous word are pleaſed to call *Amanſes*, that is, counterfeit or factitious gems, as emeralds, rubies, ſaphires, topazes, and the like. For in the making of theſe, though pure ſand or calcined cryſtal give the body, yet it is for the moſt part ſome metalline or mineral calx, mingled in a ſmall proportion, that gives the colour. But though I have many years ſince taken delight to divert myſelf with this pleaſing art, and have ſeen very pretty productions of it, yet beſides that I fear I have now forgot moſt of the little ſkill I had in it, this is no place to entertain you with what would rather take up an entire diſcourſe, than be comprehended in an annotation. Wherefore the few things, which I ſhall here take notice of to you, are only what belong to the preſent argument, namely,

FIRST, that I have often obſerved, that calcined lead colliquated with fine white ſand or cryſtal, reduced by ignitions and ſubſequent extinctions in water to a ſubtile powder, will of itſelf be brought by a due decoction to give a clear maſs coloured like a German amethyſt. For though this glaſs of lead is looked upon by them, that know no better way of making *Amanſes*, as the grand work of them all; yet, which is an inconvenience, that much blemiſhes this way, the calcined lead it ſelf does not only afford matter to the *Amanſes*, but has alſo as well as other metals a colour of its own, which, as I was ſaying, I have often found to be like that of German (as many call them) not Eaſtern amethyſts.

SECONDLY, That nevertheleſs this colour may be eaſily over-powered by thoſe of divers other mineral pigments (if I may ſo call them) ſo that with glaſs of lead you may emulate (for inſtance) the freſh and lovely greenneſs of an emerald, though in divers caſes the colour, which the lead itſelf upon vitrification tends to, may vitiate that of the pigment, which you would introduce into the maſs.

THIRDLY, That ſo much even theſe colours depend upon texture, that in the glaſs of lead it ſelf made of about three parts of litharge or minium colliquated with one of very finely powdered cryſtal or ſand, we have taken pleaſure to make the mixture paſs through differing colours, as we kept it more or leſs in the fuſion. For it was not uſually till after a pretty long decoction, that the maſs attained to the amethyſtine colour.

FOURTHLY and laſtly, That the degrees of coction and other circumſtances may ſo vary the colour produced in the ſame maſs, that in a crucible that was not great I have had fragments of the ſame maſs, in ſome of which, perhaps not ſo big as a hazel-nut, you may diſcern four diſtinct colours.

ANNOTATION VI.

YOU may remember (*Pyrophilus*) that when I mentioned the three ſorts of adventitious colours of metals, I mentioned them but as the chief, not the only. For there may be other ways, which though they do not in ſo ſtrict a ſenſe belong to the adventitious colours of metals, may not inconveniently be reduced to them. And of theſe I ſhall name now a couple, without denying, that there may be more.

THE firſt may be drawn from the practice of thoſe, that dye ſcarlet. For the famouſeſt maſter in that art, either in *England* or *Holland*, has confeſſed to me, that neither others nor he can ſtrike that lovely colour, which is now wont to be called the Bow-dye, without their materials be boiled in veſſels, either made of, or lined with a particular metal. But of what I have known attempted in this kind, I muſt not as yet, for fear of prejudicing or diſpleaſing others, give you any particular account. *See the latter end of the fiftieth experiment.*

THE other way, (*Pyrophilus*) of making metals afford unobvious colours, is by imbuing divers bodies with ſolutions of them made in their proper menſtruums: as (for inſtance,) though copper plentifully diſſolved in aqua-fortis will imbue ſeveral bodies with the colour of the ſolution; yet ſome other metals will not (as I elſewhere tell you) and have often tried. Gold diſſolved in aqua regia will (which is not commonly known) dye the nails and ſkin, and hafts of knives, and other things made of ivory, not with a golden, but a purple colour, which though it manifeſt but ſlowly, is very durable,

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durable, and ſcarce ever to be waſhed out. And if I miſremember not, I have already told you in this treatiſe, that the purer cryſtals of fine ſilver made with aqua fortis, though they appear white, will preſently dye the ſkin and nails with a black, or at leaſt a very dark colour, which water will not waſh off, as it will ordinary ink from the ſame parts. And divers other bodies may the ſame way be dyed, ſome of a black, and others of a blackiſh colour.

And as metalline, ſo likewiſe mineral ſolutions may produce colours differing enough from thoſe of the liquors themſelves. I ſhall not fetch an example of this, from what we daily ſee happen in the powdering of beef, which by the brine employed about it (eſpecially if the fleſh be over-ſalted) does oftentimes appear at our tables of a green, and ſometimes of a reddiſh colour, (deep enough;) nor ſhall I inſiſt on the practice of ſome that deal in ſaltpetre, who, (as I ſuſpected, and as themſelves acknowledged to me) do, with the mixture of a certain proportion of that, and common ſalt, give a fine redneſs, not only to neats tongues, but, which is more pretty as well as difficult, to ſuch fleſh, as would otherwiſe be purely white: theſe examples, I ſay, I ſhall decline inſiſting on, as chuſing rather to tell you, that I have ſeveral times tried, that a ſolution of the ſulphur of vitriol, or even of common ſulphur, though the liquor appeared clear enough, would immediately tinge a piece of new coin, or other clean ſilver, ſometimes with a golden, ſometimes with a deeper and more reddiſh colour, according to the ſtrength of the ſolution, and the quantity of it, that chanced to adhere to the metal; which may take off your wonder, that the water of the hot ſpring at *Bath*, abounding with diſſolved ſubſtances of a very ſulphureous nature, ſhould for a while as it were gild the new or clean pieces of ſilver coin, that are for a due time immerſed in it. And to theſe may be added thoſe formerly mentioned examples of the adventitious colours of mineral bodies: which brings into my mind, that even vegetable liquors, whether by degeneration, or by altering the texture of the body that imbibes them, may ſtain other bodies with colours differing enough from their own, of which very good herbariſts have afforded us a notable example, by affirming, that the juice of alcanna being green (in which ſtate I could never here procure it) does yet dye the ſkin and nails of a laſting red. But I ſee this treatiſe is like to prove too bulky, without the addition of further inſtances of this nature.

EXPERIMENT XLIX.

MEETING the other day, *Pyrophilus*, in an Italian book, that treats of other matters, with a way of preparing what the author calls a lacca of vegetables, by which the Italians mean a kind of extract fit for painting, like that rich lacca in Engliſh commonly called lake, which is employed by painters as a glorious red: and finding the experiment not to be inconſiderable, and very defectively ſet down; it will not be amiſs to acquaint you with what ſome trials have informed us, in reference to this experiment, which both by our Italian author, and by divers of his countrymen, is looked upon as no trifling ſecret.

Take then the root called in Latin *Curcuma*, and in Engliſh turmerick, (which I made uſe of, becauſe it was then at hand, and is among vegetables fit for that purpoſe one of the moſt eaſieſt to be had;) and when it is beaten, put what quantity of it you pleaſe into fair water, adding to every pound of water about a ſpoonful or better of as ſtrong a lixivium or ſolution of pot-aſhes as you can well make, clarifying it by filtration before you put it to the decocting water. Let theſe things boil, or rather ſimmer over a ſoft fire in a clean glazed earthen veſſel, till you find by the immerſion of a ſheet of white paper (or by ſome other way of trial) that the liquor is ſufficiently impregnated with the golden tincture of the turmerick; then take the decoction off the fire, and filter or ſtrain it, that it may be clean; and leiſurely dropping into it a ſtrong ſolution of roch-allom, you ſhall find the decoction as it were curdled, and the tincted part of it either to emerge, to ſubſide, or to ſwim up and down, like little yellow flakes: and if you pour this mixture into a tunnel lined with cap-paper, the liquor, that filtred formerly ſo yellow, will now paſs clean through the filtre, leaving its tincted and as it were curdled parts in the filtre, upon which fair water muſt be ſo often poured, till you have dulcified the matter therein contained, the ſign of which dulcification is (you know) when the water, that has paſſed through it, comes from it as taſteleſs as it was poured on it. And if without filtration you would gather together the flakes of this vegetable lake, you muſt pour a great quantity of fair water upon the decoction after the affuſion of the alluminous ſolution, and you ſhall find the liquor to grow clearer, and the lake to ſettle together at the bottom, or emerge to the top of the water; though ſometimes having not poured out a ſufficient quantity of fair water, we have obſerved the lake partly to ſubſide, and partly to emerge, leaving all the middle of the liquor clear. But to make this lake fit for uſe, it muſt, by repeated affuſions of freſh water, be dulcified from the adhering ſalts, as well as that ſeparated by filtration, and be ſpread and ſuffered to dry leiſurely upon pieces of cloth, with brown paper, or chalk, or bricks under them to imbibe the moiſture. *

ANNOTATION I.

WHEREAS it is preſumed, that the magiſtery of vegetables obtained this way conſiſts but of the more ſoluble and coloured parts of the plants that afford it, I muſt take

* The curious reader that deſires further information concerning lakes, may reſort to the 7th book of *Neri's* art of glaſs, Engliſhed (6 or 7 years ſince the writing of this 49th experiment) and illuſtrated with learned obſervations, by the inquiſitive and experienced Dr. *Charles Merret*.

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the liberty to queſtion the ſuppoſition; and for my ſo doing, I ſhall give you this account.

ACCORDING to the notions (ſuch as they were) that I had concerning ſalts; allom, though to ſenſe a homogeneous body, ought not to be reckoned among true ſalts, but to be itſelf looked upon as a kind of magiſtery, in regard that as native vitriol (for ſuch I have had) contains both a ſaline ſubſtance and a metal, whether copper, or iron, corroded by it, and aſſociated with it; ſo allom, which may be of ſo near a kin to vitriol, that in ſome places of *England* (as we are aſſured by good authority the ſame ſtone will ſometimes afford both) ſeems manifeſtly to contain a peculiar kind of acid ſpirit, generated in the bowels of the earth, and ſome kind of ſtony matter diſſolved by it. And though in making our ordinary allom the workmen uſe the aſhes of a ſea-weed (vulgarly called kelp) and urine; yet thoſe, that ſhould know, inform us, that, here in *England*, there is beſides the factitious allom, allom made by nature without the help of thoſe additaments. Now, *Pyrophilus*, when I conſidered this compoſition of allom, and that alcalizate ſalts are wont to precipitate what acid ſalts have diſſolved, I could not but be prone to ſuſpect, that the curdled matter, which is called the magiſtery of vegetables, may have in it no inconſiderable proportion of a ſtony ſubſtance precipitated out of the allom by the lixivium, wherein the vegetable had been decocted. And to ſhew you, that there is no neceſſity, that all the curdled ſubſtance muſt belong to the vegetable, I ſhall add, that I took a ſtrong ſolution of allom, and having filtred it, by pouring in a convenient quantity of a ſtrong ſolution of pot-aſhes, I preſently, as I expected, turned the mixture into a kind of white curds, which being put to filtre, the paper retained a ſtony calx, copious enough, very white, and which ſeemed to be of a mineral nature, both by ſome other ſigns, and this, that little bits of it being put upon a live coal, which was gently blown whilſt they were on it, they did neither melt nor fly away, and you may keep a quantity of this white ſubſtance for a good while, (nay, for aught I can gueſs, for a very long one) in a red-hot crucible, without loſing or ſpoiling it; nor did hot water, wherein I purpoſely kept another parcel of ſuch calx, ſeem to do any more than waſh away the looſer adhering ſalts from the ſtony ſubſtance, which therefore ſeemed unlikely to be ſeparable by ablutions (though reiterated) from the precipitated parts of the vegetable, whoſe lake is intended. And to ſhew you, that there is likewiſe in allom a body, with which the fixed ſalt of the alcalizate ſolution will concoagulate into a ſaline ſubſtance differing from either of them, I ſhall add, that I have taken pleaſure to recover out of the ſlowly exhaled liquor, that paſſed through the filtre, and left the aforementioned calx behind, a body, that at leaſt ſeemed a ſalt very pretty to look on, as being very white, and conſiſting of an innumerable company of exceeding ſlender and ſhining particles, which would in part eaſily melt at the flame of a candle, and in part fly away with ſome little noiſe. But of this ſubſtance, and its odd qualities, more, perhaps, elſewhere; for now I ſhall only take notice to you, that I have likewiſe with urinous ſalts, ſuch as the ſpirit of ſal armoniac, as well as with the ſpirit of urine itſelf, nay, (if I much miſtake not) even with ſtale urine undiſtilled, eaſily precipitated ſuch a white calx, as I was formerly ſpeaking of, out of a limpid ſolution of allom: ſo that there is need of circumſpection in judging of the natures of liquors by precipitations, wherein allom intervenes; elſe we may ſometimes miſtakingly imagine, that to be precipitated out of a liquor by allom, which is rather precipitated out of allom by the liquor. And this puts me in mind to tell you, that it is not unpleaſant to behold, how quickly the ſolution of allom (or injected lumps of allom) does occaſion the ſevering of the coloured parts of the decoction from the liquor, that ſeemed to have ſo perfectly imbibed them.

ANNOTATION II.

THE above-mentioned way of making lakes we have tried not only with turmerick, but alſo with madder, which yielded us a red lake; and with rue, which afforded us an extract, of (almoſt, if not altogether) the ſame colour with that of the leaves.

BUT in regard that it is principally the alcalizate ſalt of the pot-aſhes, which enables the water to extract ſo powerfully the tincture of the decocted vegetables, I fear, that our author may be miſtaken, by ſuppoſing, that the decoction will always be of the very ſame colour with the vegetable it is made of. For lixiviate ſalts, to which pot-aſhes eminently belong, though by piercing and opening the bodies of vegetables, they prepare and diſpoſe them to part readily with their tincture; yet ſome tinctures they do not only draw out, but likewiſe alter them, as may be eaſily made appear by many of the experiments already ſet down in this treatiſe. And though allom being of an acid nature, its ſolutions may in ſome caſes deſtroy the adventitious colours produced by the alcali, and reſtore the former; yet beſides that allom is not, as I have lately ſhown, a mere acid ſalt, but a mixt body; and beſides that its operations are languid in compariſon of the activity of ſalts freed by diſtillation, or by incineration and diſſolution, from the moſt of their earthy parts, we have ſeen already examples, that in divers caſes an acid ſalt will not reſtore a vegetable ſubſtance to the colour, of which an alcalizate one had deprived it, but makes it aſſume a third very differing from both; as we formerly told you, that if ſyrup of violets were by an alcali turned green, (which colour, as I have tried, may be the ſame way produced in the violet-leaves themſelves without any relation to a ſyrup) an acid ſalt would not make it blue again, but red. And though I have, by this way of making lakes, made magiſteries (for ſuch they ſeem to be) of brazil, and as I remember of cochineal itſelf, and of other things, red, yellow, or green, which lakes were ennobled with a rich colour, and others had no bad one; yet in ſome

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ſome the colour of the lake ſeemed rather inferior than otherwiſe to that of the plant, and in others it ſeemed both very differing, and much worſe. But writing this in a time and place, where I cannot provide myſelf of flowers and other vegetables to proſecute ſuch trials in a competent variety of ſubjects, I am content not to be poſitive in delivering a judgment of this way of lakes, till experience, or you, *Pyrophilus*, ſhall have afforded me a fuller and more particular information.

ANNOTATION III.

AND on this occaſion, *Pyrophilus*, I muſt here (having forgot to do it ſooner) advertiſe you, once for all, that having written ſeveral of the foregoing experiments, not only in haſte, but at ſeaſons of the year, and in places wherein I could not furniſh myſelf with ſuch inſtruments, and ſuch a variety of materials, as the deſign of giving you an introduction into the hiſtory of colours required; it can ſcarce be otherwiſe, but that divers of the experiments, that I have ſet down, may afford you ſome matter of new trials, if you think fit to ſupply the deficiencies of ſome of them, (eſpecially the freſhly mentioned about lakes, and thoſe that concern emphatical colours;) which deficiencies, for want of being befriended with accommodations, I could better diſcern than avoid.

ANNOTATION IV.

THE uſe of allom is very great as well as familiar in the dyers trade, and I have not been ill pleaſed with the uſe I have been able to make of it, in preparing other pigments than thoſe they imploy with vegetable juices. But the lucriferous practices of dyers and other tradeſmen I do, for reaſons that you may know when you pleaſe, purpoſely forbear in this eſſay, though not ſtrictly from pointing at, yet from making it a part of my preſent work explicitely and circumſtantially to deliver; eſpecially ſince I now find (though late, and not without ſome bluſhes at my prolixity) that what I intended but for a ſhort eſſay, is already ſwelled into almoſt a volume.

EXPERIMENT L.

YET here, *Pyrophilus*, I muſt take leave to inſert an experiment, though perhaps you will think its coming in here an intruſion: For I confeſs its more proper place would have been among thoſe experiments, that were brought as proofs and applications of our notions concerning the differences of ſalts; but not having remembred to inſert it in its fitteſt place, I had rather take notice of it in this, than leave it quite unmentioned: partly, becauſe it doth ſomewhat differ from the reſt of our experiments about colours, in the way whereby it is made; and partly becauſe the grounds, upon which I deviſed it, may hint to you ſomewhat of the method I uſe in defining and varying experiments about colours. And upon this account I ſhall inform you, not only what I did, but why I did it.

I CONSIDERED then, that the work of the former experiments was either to change the colour of a body into another, or quite to deſtroy it, without giving it a ſucceſſor; but I had a mind to give you alſo a way, whereby to turn a body endued with one colour into two bodies, of colours as well as conſiſtencies, very diſtinct from each other, and that by the help of a body, that had itſelf no colour at all. In order to this, I remembred, that finding the acidity of ſpirit of vinegar to be wholly deſtroyed by its working upon minium (or calcined lead) whereby the ſaline particles of the menſtruum have their taſte and nature quite altered, I had, among other conjectures I had built upon that change, rightly concluded, that the ſolution of lead in ſpirit of vinegar would alter the colour of the juices and infuſions of ſeveral plants, much after the like manner that I had found oil of tartar to do; and accordingly I was quickly ſatisfied upon trial, that the infuſion of roſe-leaves would, by a ſmall quantity of this ſolution well mingled with it, be immediately turned into a ſomewhat ſad green.

AND further, I had often found, that oil of vitriol, though a potently acid menſtruum, will yet precipitate many bodies, both mineral and others, diſſolved not only in aqua-fortis (as ſome chymiſts have obſerved) but particularly in ſpirit of vinegar. And I have further found, that the calces or powders precipitated by this liquor were uſually fair and white.

LAYING theſe things together, it was not difficult to conclude, that if upon a good tincture of red roſe-leaves made with fair water, I dropped a pretty quantity of a ſtrong and ſweet ſolution of minium, the liquor would be turned into the like muddy green ſubſtance, as I have formerly intimated to you, that oil of tartar would reduce it to; and that if then I added a convenient quantity of good oil of vitriol, this laſt named liquor would have two diſtinct operations upon the mixture; the one, that it would precipitate that reſolved lead in the form of a white powder; the other, that it would clarify the muddy mixture, and both reſtore and exceedingly heighten the redneſs of the infuſion of roſes, which was the moſt copious ingredient of the green compoſition. And accordingly trying the experiment in a wine-glaſs ſharp at the bottom (like an inverted cone) that the ſubſiding powder might ſeem to take up the more room, and be the more conſpicuous, I found, that when I had ſhaken the green mixture, that the coloured liquor might be the more equally diſperſed, a few drops of the rectified oil of vitriol did preſently turn the opacous liquor into one that was clear and red, almoſt like a ruby, and threw down good ſtore of a powder, which, when it was ſettled, would have appeared very white, if ſome interſperſed particles of the red liquor had not a little allayed the purity, though not blemiſhed the beauty of the colour. And to ſhew you, *Pyrophilus*, that theſe effects do not flow from the oil of vitriol, as it is ſuch, but as it is a ſtrongly acid menſtruum, that has the

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the property both to precipitate lead, as well as ſome other concretes out of ſpirit of vinegar, and to heighten the colour of red roſe-leaves; I add, that I have done the ſame thing, though perhaps not quite ſo well, with ſpirit of ſalt; and that I could not do it with aqua fortis, becauſe though that potent menſtruum does, as well as the others, heighten the redneſs of roſes, yet it would not, like them, precipitate lead out of ſpirit of vinegar, but would rather have diſſolved it, if it had not found it diſſolved already.

AND as by this way we have produced a red liquor, and a white precipitate out of a dirty green magiſtery of roſe-leaves; ſo by the ſame method, you may produce a fair yellow, and ſometimes a red liquor, and the like precipitate, out of an infuſion of a curious purple colour. For you may call to mind, that in the annotation upon the 39th experiment I intimated to you, that I had with a few drops of an alcali turned the infuſion of logwood into a lovely purple. Now if inſtead of this alcali I ſubſtituted a very ſtrong and well-filtrated ſolution of minium, made with ſpirit of vinegar, and put about half as much of this liquor as there was of the infuſion of logwood, (that the mixture might afford a pretty deal of precipitate,) the affuſion of a convenient proportion of ſpirit of ſalt would (if the liquors were well and nimbly ſtirred together) preſently ſtrike down a precipitate like that formerly mentioned, and turn the liquor, that ſwam above it, for the moſt part, into a lovely yellow.

BUT for the advancing of this experiment a little further, I conſidered, that in caſe I firſt turned a ſpoonful of the infuſion of logwood purple, by a convenient proportion of the ſolution of minium, the affuſion of ſpirit of ſal-armoniack would precipitate the corpuſcles of lead concealed in the ſolution of minium, and yet not deſtroy the purple colour of the liquor; whereupon I thus proceeded: I took about a ſpoonful of the freſh tincture of logwood, (for I found, that if it were ſtale, the experiment would not always ſucceed,) and having put to it a convenient proportion of the ſolution of minium to turn it into a deep and almoſt opacous purple, I then dropped in as much ſpirit of ſal armoniack, as I gueſſed would precipitate about half or more (but not all) of the lead, and immediately ſtirring the mixture well together, I mingled the precipitated parts with the others, ſo that they fell to the bottom, partly in the form of a powder, and partly in the form of a curdled ſubſtance, that (by reaſon of the predominancy of the tinged corpuſcles over the white) retained, as well as the ſupernatant liquor, a blueiſh purple colour ſufficiently deep, and then inſtantly (but yet warily) pouring on a pretty quantity of ſpirit of ſalt, the matter firſt precipitated was, by the above ſpecified figure of the bottom of the glaſs preſerved from being reached by the ſpirituous ſalt; which haſtily precipitated upon it a new bed (if I may ſo call it) of white powder, being the remaining corpuſcles of the lead, that the urinous ſpirit had not ſtruck down. So that there appeared in the glaſs three diſtinct and very differingly coloured ſubſtances; a purple or violet-coloured precipitate at the bottom, a white and carnation (ſometimes a variouſly coloured) precipitate over that, and at the top of all a tranſparent liquor of a lovely yellow, or red.

THUS you ſee, *Pyrophilus*, that though to ſome I may have ſeemed to have lighted on this (50th) Experiment by chance, and though others may imagine, that to have excogitated it muſt have proceeded from ſome extraordinary inſight into the nature of colours; yet indeed the deviſing of it need not be looked upon as any great matter, eſpecially to one, that is a little verſed in the notions I have in theſe, and other papers hinted concerning the differences of ſalts. And perhaps I might add, upon more than conjecture, that theſe very notions, and ſome particulars ſcatteringly delivered in this treatiſe, being ſkilfully put together, may ſuggeſt divers matters (at leaſt) about colours, that will not be altogether deſpicable. But thoſe hinted, *Pyrophilus*, I muſt now leave ſuch as you to proſecute, having already ſpent far more time than I intended to allow myſelf, in acquainting you with particular experiments and obſervations concerning the changes of colour; to which I might have added many more, but that I hope I may have preſented you with a competent number, to make out, in ſome meaſure, what I have, at the beginning of this eſſay, either propoſed as my deſign in this tract, or delivered as my conjectures concerning theſe matters. And it not being my preſent deſign, as I have more than once declared, to deliver any poſitive hypotheſis or ſolemn theory of colours, but only to furniſh you with ſome experiments towards the framing of ſuch a theory; I ſhall add nothing to what I have ſaid already, but a requeſt, that you would not be forward to think I have been miſtaken in any thing I have delivered as matter of fact concerning the changes of colours, in caſe you ſhould not, every time you try it, find it exactly to ſucceed. For beſides the contingencies, to which we have elſewhere ſhewn ſome other experiments to be obnoxious, the omiſſion or variation of a ſeemingly inconſiderable circumſtance may hinder the ſucceſs of an experiment, wherein no other fault has been committed. Of which truth I ſhall only give you that ſingle and almoſt obvious, but yet illuſtrious inſtance of the art of dying ſcarlets: for though you ſhould ſee every ingredient, that is uſed about it; though I ſhould particularly inform you of the weight of each; and though you ſhould be preſent at the kindling of the fire, and at the increaſing and remitting of it, whenever the degree of heat is to be altered; and though (in a word) you ſhould ſee every thing done ſo particularly, that you would ſcarce harbour the leaſt doubt of your comprehending the whole art; yet if I ſhould not diſcloſe to you, that the veſſels, that immediately contain the tinging ingredients, are to be made of or to be lined with tin, you would never be able, by all that I could tell you elſe (at leaſt, if the famouſeſt and candideſt

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dideſt artificers do not ſtrangely delude themſelves) to bring your tincture of cochineal to dye a perfect ſcarlet. So much depends upon the very veſſel, wherein the tinging matters are boiled, and ſo great an influence may an unheeded circumſtance have on the ſucceſs of experiments concerning colours.

A ſhort Account of ſome *OBSERVATIONS* made by Mr. BOYLE, about a DIAMOND, that *ſhines* in the *Dark*.

Firſt encloſed in a *LETTER* written to a FRIEND:

And now, together with it, annexed to the foregoing Treatiſe, upon the ſcore of the affinity between *LIGHT* and *COLOURS*.

A Copy of the LETTER, that Mr. BOYLE wrote to Sir ROBERT MORRAY, to accompany the *Obſervations* touching the *Shining Diamond*.

SIR,

THOUGH Sir *Robert Morray* and Monſieur *Zulichem* be perſons, that have deſerved ſo well of the commonwealth of learning, that I ſhould think myſelf unworthy to be looked upon as a member of it, if I declined to obey them, or to ſerve them; yet I ſhould not without reluctancy ſend you the notes you deſire for him, if I did not hope, that you will tranſmit, together with them, ſome account, why they are not leſs unworthy of his peruſal: which that you may do, I muſt inform you, how the writing of them was occaſioned, which in ſhort was thus. As I was juſt going out of town, hearing that an ingenious gentleman of my acquaintance, lately returned from *Italy*, had a diamond, that being rubbed, would ſhine in the dark, and that he was not far off; I ſnatched time from my occaſions to make him a viſit; but finding him ready to go abroad, and having in vain tried to make the ſtone yield any light in the day-time, I borrowed it of him for that night, upon condition to reſtore it him within a day or two at furtheſt, at *Greſham* College, where we appointed to attend the meeting of the ſociety, that was then to be at that place. And hereupon I haſted that evening out of town, and finding after ſupper, that the ſtone, which in the day-time would afford no diſcernable light, was really conſpicuous in the dark, I was ſo taken with the novelty, and ſo deſirous to make ſome uſe of an opportunity, that was like to laſt ſo little a while, that though at that time I had no body to aſſiſt me but a foot-boy, yet ſitting up late, I made a ſhift that night to try a pretty number of ſuch of the things, that then came into my thoughts, as were not in that place and time unpracticable. And the next day, being otherwiſe employed, I was fain to make uſe of a drouſy part of the night to ſet down haſtily in writing what I had obſerved; and without having the time in the morning to ſtay the tranſcribing of it, I ordered the obſervations to be brought after me to *Greſham* College; where you may remember, that they were, together with the ſtone itſelf, ſhown to the Royal Society, by which they had the good fortune not to be diſliked, though ſeveral things were, through haſte, omitted, ſome of which you will find in the margin of the incloſed paper. The ſubſtance of this ſhort narrative I hope you will let Monſieur *Zulichem* know, that he may be kept from expecting any thing of finiſhed in the obſervations, and be diſpoſed to excuſe the want of it. But ſuch as they are, I hope they will prove (without a clinch) luciferous experiments, by ſetting the ſpeculations of the curious on work, in a diligent inquiry after the nature of light, towards the diſcovery of which, perhaps, they have not yet met with ſo conſiderable an experiment; ſince here we ſee light produced in a dead and opacous body, and that not as in rotten wood, or in fiſhes, or as in the Bolonian ſtone, by a natural corruption, or by a violent deſtruction of the texture of the body, but by ſo ſlight a mechanical operation upon its texture, as we ſeem to know what it is, and as is immediately performed, and that ſeveral ways, without at all prejudicing the body, or making any ſenſible alterations in its manifeſt qualities. And I am the more willing to expoſe my haſty trials to Monſieur *Zulichem*, and to you, becauſe he, being upon the conſideration of dioptricks, ſo odd a phænomenon relating to the ſubject, as probably he treats of, Light, will, I hope, excite a perſon to conſider it, that is wont to conſider things he treats of very well. And for you, Sir, I hope you will both recruit and perfect the obſervations you receive; for you know, that I cannot add to them, having a good while ſince reſtored to Mr. *Clayton* the ſtone, which, though it be now in the hands of a prince, that ſo highly deſerves,

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deſerves, by underſtanding them, the greateſt curioſities; yet he vouchſafes you that acceſs to him, as keeps me from doubting, you may eaſily obtain leave to make further trials with it, of ſuch a monarch as ours, that is not more inquiſitive himſelf, than a favourer of them that are ſo. I doubt not but theſe notes will put you in mind of the motion you made to the ſociety, to impoſe upon me the taſk of bringing in what I had on other occaſions obſerved concerning ſhining bodies. But though I deny not, that I ſometimes made obſervations about the Bolonian ſtone, and tried ſome experiments about ſome other ſhining bodies; yet the ſame reaſons, that reduced me then to be unwilling to receive even their commands, muſt now be my apology for not anſwering your expectations, namely, the abſtruſe nature of light, and my being already overburdened, and but too much kept employed by the urgency of the preſs, as well as by more concerning and diſtracting occaſions. But yet I will tell you ſome part of what I have met with in reference to the ſtone, of which I ſend you an account. Becauſe I find, on the one ſide, that a great many think it no rarity, upon a miſtaken perſuaſion, that not only there are a ſtore of carbuncles, of which this is one; but that all diamonds, and other gliſtering jewels, ſhine in the dark. Whereas, on the other ſide, there are very learned men, who (plauſibly enough) deny, that there are any carbuncles or ſhining ſtones at all.

AND certainly, thoſe judicious men have much more to ſay for themſelves, than the others commonly plead; and therefore did deſervedly look upon Mr. *Clayton*'s diamond as a great rarity. For not only *Boëtius de Boot*, who is judged the beſt author on this ſubject, aſcribes no ſuch virtue to diamonds, but begins what he delivers of carbuncles, with this paſſage; *Magna fama eſt carbunculi. Is vulgo putatur in tenebris carbonis inſtar lucere; fortaſſis quia pyropus ſeu anthrax appellatus à veteribus fuit. Verum hactenus nemo unquam verè aſſerere auſus fuit, ſe gemmam noctu lucentem vidiſſe. Garcias ab Horto proregis Indiæ medicus refert ſe allocutum fuiſſe, qui ſe vidiſſe affirmarent. Sed iis fidem non habuit.* And a later author, the diligent and judicious *Johannes de Laet*, in his chapter of carbuncles and of rubies, has this paſſage; *Quia autem carbunculi, pyropi & anthraces à veteribus nominantur, vulgo creditum fuit, carbonis inſtar in tenebris lucere, quod tamen nullâ gemmâ hactenus deprehenſum, licet à quibuſdam temerè jactetur.* And the recenteſt writer I have met with on this ſubject, *Olaus Wormius*, in his account of his well-furniſhed *Muſæum*, does, where he treats of rubies, concur with the former writers by theſe words: *Sunt, qui rubinum veterum carbunculum eſſe exiſtimant, ſed deeſt una illa nota, quod in tenebris inſtar anthracis non luceat: Aſt talem carbunculum in rerum naturâ non inveniri major pars authorum exiſtimant. Licet unum aut alterum in India apud magnates quoſdam reperiri ſcribant, cum tamen ex aliorum relatione id habeant ſaltem, ſed ipſi non viderint.* In confirmation of which I ſhall only add, that hearing of a ruby, ſo very vivid, that the jewellers themſelves have ſeveral times begged leave of the fair lady, to whom it belonged, that they might try their choiceſt rubies by comparing them with that, I had the opportunity, by the favour of this lady and her huſband, (both which I have the honour to be acquainted with) to make a trial of this famous ruby in the night, and in a room well darkned, but not only could not diſcern any thing of light, by looking on the ſtone before any thing had been done to it, but could not, by all my rubbing, bring it to afford the leaſt glimmering of light.

Boëtius de Boot. Gem. & Lapid. Hiſtor. Lib. 2. Cap. 8.

Muſæi Wormiani, Cap. 17.

BUT, Sir, though I be very backward to admit ſtrange things for truths, yet I am not very forward to reject them as impoſſibilities; and therefore I would not diſcourage any from making further inquiry, whether or no there be really *in rerum natura* any ſuch thing as a true carbuncle or ſtone, that without rubbing will ſhine in the dark. For if ſuch a thing can be found, it may afford no ſmall aſſiſtance to the curious in the inveſtigation of light, beſides the nobleneſs and rarity of the thing itſelf. And though *Vartomannus* was not an eye-witneſs of what he relates, that the king of *Pegu*, one of the chief kings of the *Eaſt-Indies*, had a true carbuncle of that bigneſs and ſplendour, that it ſhined very gloriouſly in the dark; and though *Garcias ab Horto*, the *Indian* Vice-Roy's phiſician, ſpeaks of another carbuncle, only upon the report of one, that he diſcourſed with, who affirmed himſelf to have ſeen it; yet as we are not ſure, that theſe men, that gave themſelves out to be eye-witneſſes, ſpeak true, yet they may have done ſo for aught we know to the contrary. And I could preſent you with a much conſiderabler teſtimony to the ſame purpoſe, if I had the permiſſion of a perſon concerned, without whoſe leave I muſt not do it. I might tell you, that *Marcus Paulus Venetus* (whoſe ſuppoſed fables divers of our later travellers and navigators have ſince found to be truths) ſpeaking of the king of *Zeilan*, that then was, tells us, that he was ſaid to have the beſt ruby in the world, a palm long, and as big as a man's arm, without ſpot, ſhining like a fire: and he ſubjoins, that the Great Cham, under whom *Paulus* was a conſiderable officer, ſent and offered the value of a city for it; but the king anſwered, he would not give it for the treaſure of the world, nor part with it, having been his anceſtors. And I could add, that in the relation made by two Ruſſian Coſſacks of their journey into *Catay*, written to their emperor, they mention their having been told by the people of thoſe parts, that their king had a ſtone, which lights as the ſun both day and night, called in their language *Sarra*, which thoſe Coſſacks interpret a ruby. But theſe relations are too uncertain for me to build any thing upon; and therefore I ſhall proceed to tell you, that there came hither, about two years ſince, out of *America*, the governour of one of the principal colonies there, an ancient virtuoſo, and one that has the honour to be a member of the Royal Society: this gentleman, finding ſome of the chief affairs of his country committed to another and me, made

Purchas's *Pilgrim, lib.* 1 *cap.* 4. *pag.* 104.

In the year 1619.

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me divers viſits; and in one of them, when I inquired what rare ſtones they had in thoſe parts of the *Indies* he belonged to, he told me, that the Indians had a tradition, that in a certain hardly acceſſible hill, a pretty way up in the country, there was a ſtone, which in the night-time ſhined very vividly, and to a great diſtance; and he aſſured me, that though he thought it not fit to venture himſelf ſo far among thoſe ſavages, yet he purpoſely ſent thither a bold Engliſhman, with ſome natives, to be his guides; and that this meſſenger brought him back word, that at a diſtance from the hillock he had plainly perceived ſuch a ſhining ſubſtance as the Indians tradition mentioned; and being ſtimulated by curioſity, had ſlighted thoſe ſuperſtitious fears of the inhabitants, and with much ado, by reaſon of the difficulty of the way, had made a ſhift to clamber up to that part of the hill, where, by a very heedful obſervation, he ſuppoſed himſelf to have ſeen the light. But whether 'twere, that he had miſtaken the place, or for ſome other reaſon, he could not find it there; though when he was returned to his former ſtation, he did again ſee the light ſhining in the ſame place where it ſhone before. A further account of this light I expect from the gentleman, that gave me this, who lately ſent me the news of his being landed in that country. And though I reſerve to my ſelf a full liberty of believing no more than I ſee cauſe, yet I do the leſs ſcruple to relate this, becauſe a good part of it agrees well enough with another ſtory, that I ſhall in the next place have occaſion to ſubjoin: in order whereunto, I ſhall tell you, that though the learned authors I formerly mentioned, tell us, that no writer has affirmed his having himſelf ſeen a real carbuncle, yet, conſidering the light of Mr. *Clayton*'s diamond, it recalled into my mind, that ſome years before, when I was inquiſitive about ſtones, I had met with an old Italian book highly extolled to me by very competent judges; and that, though the book was very ſcarce, I had purchaſed it at a dear rate, for the ſake of a few conſiderable paſſages I met with in it, and particularly one, which being very remarkable in itſelf, and pertinent to our preſent argument, I ſhall put it for you, though not word for word, which I fear I have forgot to do, yet as to the ſenſe, into Engliſh.

'HAVING promiſed, (ſays our author) 'to 'ſay ſomething of that moſt precious ſort of 'jewels, carbuncles, becauſe they are very 'rarely to be met with, we ſhall briefly deliver 'what we know of them. In *Clement* the VIIth's 'time I happened to ſee one of them at a cer- 'tain Raguſian merchant's, named *Beigoio di* 'Bona: this was a carbuncle white, of that 'kind of whiteneſs, which we ſaid was to be 'found in thoſe rubies, of which we made 'mention a little above,' (where he had ſaid, that thoſe rubies had a kind of livid whiteneſs, or paleneſs, like that of a Calcidonian) 'but it 'had in it a luſtre ſo pleaſing, and ſo marvel- 'lous, that it ſhined in the dark, but not as 'much as coloured carbuncles; though it be 'true, that in an exceeding dark place I ſaw 'it ſhine in the manner of fire almoſt gone 'out. But as for coloured carbuncles, it has 'not been my fortune to have ſeen any: where- 'fore I will only ſet down what I learned a- 'bout them, diſcourſing in my youth with a 'Roman gentleman of ancient experience in 'matters of jewels, who told me, that one '*Jacopo Cola* being by night in a vineyard of 'his, and eſpying ſomething in the midſt of 'it, that ſhined like a little glowing coal, at 'the foot of a vine, went near towards the 'place, where he thought himſelf to have ſeen 'that fire; but not finding it, he ſaid, that 'being returned to the ſame place, whence he 'had firſt deſcried it, and perceiving there the 'ſame ſplendor as before, he marked it ſo 'heedfully, that he came at length to it, 'where he took up a very little ſtone, which 'he carried away with tranſports and joy. 'And the next day, carrying it about to ſhow 'it divers of his friends, whilſt he was relating 'after what manner he found it, there caſually 'intervened a Venetian embaſſador, exceed- 'ingly expert in jewels, who preſently know- 'ing it to be a carbuncle, did craftily, before 'he and the ſaid *Jacopo* parted, (ſo that there 'was no body preſent, that underſtood the 'worth of ſo precious a gem) purchaſe it for 'the value of ten crowns, and the next day 'left *Rome* to ſhun the being neceſſitated to re- 'ſtore it; and, as he affirmed, it was known 'within ſome while after, that the ſaid Vene- 'tian gentleman did, in *Conſtantinople*, ſell 'that carbuncle to the then Grand Signior, 'newly come to the empire, for a hundred 'thouſand crowns.'

Benvenuto Cellini nell Arte del Gioiellare, lib. 1. pag. 10.

AND this is what I can ſay concerning carbuncles; and this is not a little at leaſt as to the firſt part of this account, where our *Cellini* affirms himſelf to have ſeen a real carbuncle with his own eyes, eſpecially ſince this author appears wary in what he delivers, and is inclined rather to leſſen, than increaſe the wonder of it. And his teſtimony is the more conſiderable, becauſe though he were born a ſubject neither to the pope nor the then king of *France*, (that royal virtuoſo *Francis* I.) yet both the one and the other of thoſe princes imployed him much about making of their nobleſt jewels. What is now reported concerning a ſhining ſubſtance to be ſeen in one of the iſlands about *Scotland*, were very improper for me to mention to Sir *Robert Morray*, to whom the firſt information was originally brought, and from whom I expect a farther (for I ſcarce dare expect a convincing) account of it. But I muſt not omit, that ſome virtuoſi queſtioning me the other day at *Whitehall* about Mr. *Clayton*'s diamond, and meeting amongſt them an ingenious Dutch gentleman, whoſe father was long embaſſador for the *Netherlands* in *England*, I learned of him, that he is acquainted with a perſon, whoſe name he told, (but I do not well remember it,) who was admiral of the Dutch in the *Eaſt-Indies*, and who aſſured this gentleman, Monſieur *Boreel*, that at his return from thence, he brought back with him into *Holland* a ſtone, which though it looked but like a pale dull diamond,

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diamond, ſuch as he ſaw Mr. *Clayton*'s to be, yet was it a real carbuncle; and did without rubbing ſhine ſo much, that when the admiral had occaſion to open a cheſt, which he kept under deck in a dark place, where it was forbidden to bring candles for fear of miſchances, as ſoon as he opened the trunk, the ſtone would, by its native light, ſhine ſo as to illuſtrate a great part of it. And this gentleman having very civilly and readily granted me the requeſt I made him, to write to the admiral, who is yet alive in *Holland*, (and probably may ſtill have the jewel by him,) for a particular account of this ſtone, I hope ere long to receive it; which will be the more welcome to me, not only becauſe ſo unlikely a thing needs a clear evidence, but becauſe I have had ſome ſuſpicion, that (ſuppoſing the truth of the thing) what may be a ſhining ſtone in a very hot country, as the *Eaſt-Indies*, may perhaps ceaſe to be ſo (at leaſt in certain ſeaſons) in one as cold as *Holland*. For I obſerved in the diamond I ſend you an account of, that not only rubbing, but a very moderate degree of warmth, though excited by other ways, would make it ſhine a little. And it is not impoſſible, that there may be ſtones as much more ſuſceptible than that, of the alterations requiſite to make a diamond ſhine, as that appears to be more ſuſceptible of them than ordinary diamonds. And I confeſs to you, that this is not the only odd ſuſpicion, (for they are not ſo much as conjectures,) that what I tried upon this diamond ſuggeſted to me. For not here to entertain you with the changes I think may be effected even in harder ſort of ſtones, by ways not vulgar, nor very promiſing, becauſe I may elſewhere have occaſion to ſpeak of them, and this letter is but too prolix already; that which I ſhall now acknowledge to you is, that I began to doubt, whether there may not in ſome caſes be ſome truth in what is ſaid of the right turquois, that it often changes colour as the wearer is ſick or well, and manifeſtly loſes its ſplendour at his death. For when I found, that even the warmth of an affriction, that laſted not above a quarter of a minute, nay, that of my body, (whoſe conſtitution, you know, is none of the hotteſt) would make a manifeſt change in the ſolideſt of ſtones, a diamond; it ſeemed not impoſſible, that certain warm and ſaline ſteams, iſſuing from the body of a living man, may by their plenty or paucity, or by their peculiar nature, or by the total abſence of them, diverſify the colour and the ſplendour of ſo ſoft a ſtone as the turquois. And though I admired to ſee, that I know not how many men, otherwiſe learned, ſhould confidently aſcribe to jewels ſuch virtues, as ſeem no way compatible to inanimate agents, if to any corporeal ones at all; yet as to what is affirmed concerning the turquois's changing colour, I know not well how to reject the affirmation of ſo learned (and which in this caſe is much more conſiderable) ſo judicious a lapidary as *Boetius de Boot* *, who upon his own particular and repeated experience delivers ſo memorable a narrative of the turquois's changing colour, that I cannot but think it worth your peruſal; eſpecially ſince a much later and very experienced author, *Olaus Wormius*, where he treats of that ſtone, confirms it with this teſtimony: *Imprimis memorandum exemplum, quod Anſhelmus Boëtius de ſeipſo refert, tam mutati coloris quam à caſu preſervationis. Cui & ipſe haud diſſimile adferre poſſum, niſi ex Anſhelmo petitum quis putaret.* I remember, that I ſaw two or three years ſince a turquois (worn in a ring) wherein there were ſome ſmall ſpots, which the virtuoſo, whoſe it was, aſſured me he had obſerved to grow ſometimes greater, ſometimes leſs, and to be ſometimes in one part of the ſtone, ſometimes in another. And I having encouraged to make pictures from time to time of the ſtone, and of the ſituation of the cloudy parts, that ſo their motion may be more indiſputable, and better obſerved, he came to me about the middle of this very week, and aſſured me, that he had, as I wiſhed, made from time to time ſchemes or pictures of the differing parts of the ſtone; whereby the ſeveral removes and motions of the above mentioned clouds are very manifeſt, though the cauſe ſeemed to him very occult. Theſe pictures he has promiſed to ſhow me, and is very ready to put the ſtone itſelf into my hands. But the ring having been the other day caſually broken upon his finger, unleſs it can be taken out, and ſet again without any conſiderable heat, he is loth to have it meddled with, for fear its peculiarity ſhould be thereby deſtroyed. And poſſibly his apprehenſion would have been ſtrengthened, if I had had opportunity to tell him what is related by the learned *Wormius* of an acquaintance of his, that had a nephritick ſtone, of whoſe eminent virtues he had often experience even in himſelf, and for that cauſe wore it ſtill about his wriſt; and yet going upon a time into a bath of fair water only,

Olaus Wormius *in Muſæ.* 18 pag. 186.

Muſeum Worm. pag. 99.

* *The narrative in the author's own words, is this:* Ego (*ſays he*) ſanctè affirmare poſſum me unam aureo annulo incluſam perpetuo geſtare, cujus facultatem (ſi gemmæ eſt) nunquam ſatis admirari potui. Geſtaverat enim ante triginta annos Hiſpanus quidem non procul à paternis ædibus habitans. Is cum vitâ functus eſſet, & ipſius ſupellex (ut moris apud nos eſt) venum expoſita eſſet, inter cætera etiam turcois exponebatur. Verum nemo (licet complures eo concurriſſent, ut eam propter coloris elegantiam, quam vivo domino habuerat, emerent) ſibi emptam voluit, priſtinum enim nitorem & colorem prorſus amiſerat, ut potius malachites, quam turcois videretur. Aderat tum temporis gemmæ habendæ deſiderio etiam parens & frater meus, qui antea ſæpius gratiam & elegantiam ipſius viderant, mirabundi eam nunc tam eſſe deformem: emit eam nihilominus pater, ſatiſque vili pretio, qua omnibus contemptui erat, ac præſentes non eam eſſe quam Hiſpanus geſtarat, arbitrarentur. Domum reverſus pater, qui tam turpem gemmam geſtare ſibi indecorum putabat, eam mihi dono dat, inquiens; Quandoquidem, fili mi, vulgi fama eſt, turcoidem, ut facultates ſuas exercere poſſit, dono dari debere, tibi eam devoveo: ego acceptam gemmam ſculptori trado, ut gentilitia mea inſignia illi, quemadmodum fieri ſolet, in jaſpide chalcedonio, aliiſque ignobilioribus gemmis, inſculperet. Turpe enim exiſtimabam, hujuſmodi gemmâ ornatus gratia, dum gratiam nullam haberet, uti. Paret ſculptor, redditque gemmam, quam geſto pro annulo ſignatorio. Vix per menſem geſtaram, redit illi priſtinus color, ſed non ita nitens propter ſculpturam, ac inæqualem ſuperficiem. Miramur omnes gemmam, atque id præcipuè, quod color indies pulchrior fieret. Id quià obſervabam, nunquam fere eam à manu depoſui, ita ut nunc adhuc eandem geſtem.

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only, wherein certain herbs had been boiled, the ſtone, by being wetted with this decoction, was deprived of all its virtue; whence *Wormius* takes occaſion to advertiſe the ſick, to lay by ſuch ſtones, whenſoever they make uſe of a bath. And we might expect to find turquois likewiſe, eaſily to be wrought upon in point of colour, if that were true, which the curious *Antonino Neri*, in his ingenious *Arte Vetraria*, teaches of it; namely, that turquois's diſcoloured, and grown white, will regain and acquire an excellent colour, if you but keep them two or three days at moſt covered with oil of ſweet almonds, kept in a temperate heat by warm aſhes: I ſay, if it were true, becauſe I doubt whether it be ſo, and have not as yet had opportunity to ſatisfy my ſelf by trials; becauſe I find, by the confeſſion of the moſt ſkilful perſons, among whom I have laid out for turquoiſes, that the true ones are great rarities, though others be not at all ſo. And therefore I ſhall now only mind you of one thing, that you know as well as I, namely, that the rare ſtone, which is called *Oculus Mundi*, if it be good in its kind, will have ſo great a change made in its texture by being barely left a while in the languideſt of liquors, common water, that from opacous it will become tranſparent, and acquire a luſtre of which, it will again be deprived, without uſing any other art or violence, by leaving it a while in the air. And before experience had ſatisfied us of the truth of this, it ſeemed as unlikely, that common water or air ſhould work ſuch great changes in that gem, as it now ſeems that the effluviums of a human body ſhould effect leſſer changes in a turquois, eſpecially if more ſuſceptible of them, than other ſtones of the ſame kind. But both my watch and my eyes tell me, that it is now high time to think of going to ſleep; matters of this nature will be better, as well as more eaſily, cleared by conference than writing. And therefore ſince I think you know me too well to make it needful for me to diſclaim credulity, notwithſtanding my having entertained you with all theſe extravagancies; for you know well, how wide a difference I am wont to put betwixt things, that barely may be, and things that are; and between thoſe relations, that are but not unworthy to be inquired into, and thoſe that are not worthy to be actually believed; without making apologies for my ravings, I ſhall readily comply with the drowſineſs, that calls upon me to releaſe you: and the rather becauſe Monſieur *Zulichem* being concerned in your deſire to know the few things I have obſerved about the ſhining ſtone; to entertain thoſe with ſuſpicions, that are accuſtomed not to acquieſce but in demonſtrations, were a thing, that cannot be looked upon as other than very improper by,

Arte Vetraria, lib. 7. cap. 102.

SIR,

Your moſt affectionate and

moſt faithful ſervant,

R. BOYLE.

OBSERVATIONS made * this 27th of *October*, 1663. about Mr. *Clayton*'s Diamond.

BEING looked on in the † day-time, though in a bed, whoſe curtains were carefully drawn, I could not diſcern it to ſhine at all, though well rubbed; but about a little after ſun-ſet, whilſt the twilight yet laſted, nay, this morning a pretty while after ſun-riſing, (but before I had been abroad in the more freely inlightned air of the chamber) I could upon a light affriction eaſily perceive the ſtone to ſhine.

2. THE candles being removed, I could not in a dark place diſcern the ſtone to have any light, when I looked on it, without having rubbed or otherwiſe prepared it.

3. BY two white pebbles, though hard rubbed, one againſt another, nor by the long and vehement affriction of rock cryſtal againſt a piece of red cloth, nor yet by rubbing two diamonds ſet in a ring, as I had rubbed this ſtone, I could produce any ſenſible degree of light.

4. I FOUND this diamond hard enough, not only to enable me to write readily with it upon glaſs, but to grave on rock-cryſtal it ſelf.

5. I FOUND ‡ this to have, like other diamonds, an electrical faculty.

6. BEING rubbed upon my clothes, as is uſual for the exciting of amber, wax, and other electrical bodies, it did in the dark manifeſtly ſhine like rotten wood, or the ſcales of whitings, or other putrified fiſh.

7. BUT this conſpicuouſneſs was fainter than that of the ſcales and ſlabber (if I may ſo call it) of whitings, and much fainter than the light of a glow-worm, by which I have been ſometimes able to read a ſhort word; whereas after an ordinary affriction of this diamond, I was not able to diſcern diſtinctly by the

* Theſe were brought in and read before the Royal Society, (the day following) *Oct.* 28. 1663.

The ſtone it ſelf being to be ſhown to the Royal Society, when the obſervations were delivered, I was willing (being in haſte) to omit the deſcription of it; which is in ſhort; That it was a flat or table diamond, of about a third part of an inch in length, and ſomewhat leſs in breadth; that it was a dull ſtone, and of a very bad water, having in the day-time very little of the vividneſs of even ordinary diamonds, and being blemiſhed with a whitiſh cloud about the middle of it, which covered near a third part of the ſtone.

† Haſte made me forget to take notice, that I went abroad the ſame morning, the ſun ſhining forth clear enough, to look upon the diamond through a microſcope, that I might try whether by that magnifying glaſs any thing of peculiar could be diſcerned in the texture of the ſtone, and eſpecially of the whitiſh cloud, that poſſeſt a good part of it. But for all my attention I could not diſcover any peculiarity worth mentioning.

‡ 5. For it drew light bodies like amber, jet, and other concretes, that are noted to do ſo; but its attractive power ſeemeed inferior to theirs.

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the light of it any of the neareſt bodies. And this glimmering alſo did very manifeſtly and conſiderably decay preſently, upon the ceaſing of the affriction, though the ſtone continued viſible ſome while after.

8. BUT if it were rubbed upon a convenient body for a pretty while, and briſkly enough, I found the light would be for ſome moments much more conſiderable, almoſt like the light of a glow-worm; inſomuch that after I ceaſed rubbing, I could with a chafed ſtone exhibit a little luminous circle, like that, but not ſo bright as that, which children make by moving a ſtick fired at the end: and in this caſe it would continue viſible about ſeven or eight times as long as I had been in rubbing it.

9. I FOUND, * that holding it a while near the flame of a candle, (from which yet I was careful to avert my eyes) and being immediately removed into the dark, it diſcloſed ſome faint glimmering, but inferior to that it was wont to acquire by rubbing. And afterward holding it near a fire, that had but little flame, I found the ſtone to be rather leſs than more excited, than it had been by the candle.

10. I LIKEWISE endeavoured to make it ſhine, by holding it a pretty while in a very dark place, over a thick piece of iron; that was well heated, but not to that degree as to be viſibly ſo. And though at length I found, that by this way alſo the ſtone acquired ſome glimmering, yet it was leſs than by either of the other ways above-mentioned.

11. I ALSO brought it to ſome kind of glimmering light, by taking it into bed with me, and holding it a good while upon a warm part of my naked body.

12. To ſatisfy myſelf, whether the motion introduced into the ſtone did generate the light upon the account of its producing heat there, I held it near the flame of a candle, till it was qualified to ſhine pretty well in the dark; and then immediately I applied a ſlender hair, to try whether it would attract it, but found not that it did ſo: though if it were made to ſhine by rubbing, it was, as I formerly noted, electrical. And for further confirmation, though I once purpoſely kept it ſo near the hot iron I juſt now mentioned, as to make it ſenſibly warm, yet it ſhined more dimly than it had done by affriction, or the flame of a candle, though by both thoſe ways it had not acquired any warmth that was ſenſible.

13. HAVING purpoſely rubbed it upon ſeveral bodies differing as to colour and as to texture, there ſeemed to be ſome little diſparity in the excitation (if I may ſo call it) of light. Upon white and red cloaths it ſeemed to ſucceed beſt, eſpecially in compariſon of black ones.

14. BUT to try what it would do rubbed upon bodies more hard, and leſs apt to yield heat, upon a light affriction, than cloth, I firſt rubbed it upon a white wooden box, by which it was excited, and afterwards upon a piece of purely glazed earth; which ſeemed, during the attrition, to make it ſhine better than any of the other bodies had done, without excepting the white ones; which I add, leſt the effect ſhould be wholly aſcribed to the diſpoſition white bodies are wont to have to reflect much light.

15. HAVING † well excited the ſtone, I nimbly plunged it under water, that I had provided for that purpoſe, and perceived it to ſhine whilſt it was beneath the ſurface of that liquor, and this I did divers times. But when I endeavoured to produce a light by rubbing it upon the lately mentioned cover of the box, the ſtone and it being both held beneath the ſurface of the water, I did not well ſatisfy myſelf in the event of the trial: but this I found, if I took the ſtone out, and rubbed it upon a piece of cloth, it would not, as elſe it was wont to do, preſently acquire a luminouſneſs, but needed to be rubbed manifeſtly much longer, before the deſired effect was found.

16. I ALSO ‡ tried ſeveral times, that by covering it with my warm ſpittle (having no warm water at hand) it did not loſe his light.

17. FINDING that by rubbing the ſtone with the flat ſide downwards, I did, by reaſon of the opacity of the ring, and the ſudden decay of light upon the ceaſing of the attrition, probably loſe the ſight of the ſtone's greateſt vividneſs; and ſuppoſing that the commotion made in one part of the ſtone will be eaſily propagated all over; I ſometimes held the piece of cloth, upon which I rubbed it, ſo, that one ſide of the ſtone was expoſed to my eye, whilſt I was rubbing the other; whereby it appeared more vivid than formerly, and to make luminous tracts by its motions to and fro. And ſometimes holding the ſtone upwards, I rubbed its broad ſide with a fine ſmooth piece of tranſparent horn, by which means the light through that diaphanous ſubſtance did, whilſt I was actually rubbing the ſtone, appear ſo briſk, that ſometimes, and in ſome places, it ſeemed to have little ſparks of fire.

18. I TOOK alſo a piece of flat blue glaſs, and having rubbed the diamond well upon a cloath, and nimbly clapt the glaſs upon it, to try whether, in caſe the light could pierce it, it would by appearing green, or of ſome other colour

* 9. We durſt not hold it in the flame of a candle, no more than put it into a naked fire; for fear too violent a heat (which has been obſerved to ſpoil many other precious ſtones) ſhould vitiate and impair a jewel, that was but borrowed, and was ſuppoſed to be the only one of its kind.

† 15. We likewiſe plunged it, as ſoon as we had excited it, under liquors of ſeveral ſorts, as ſpirit of wine, oils both chymical and expreſſed, an acid ſpirit, and, as I remember, an alcalizate ſolution; and found not any of thoſe various liquors to deſtroy its ſhining property.

‡ 16. Having found by this obſervation, that a warm liquor would not extinguiſh light in the diamond, I thought fit to try, whether, by reaſon of its warmth, it would not excite it; and divers times I found, that if it were kept therein, till the water had leiſure to commnnicate ſome of its heat to it, it would often ſhine as ſoon as it was taken out; and probably we ſhould have ſeen it ſhine more, whilſt it was in the water, if ſome degree of opacity, which heated water is wont to acquire, upon the ſcore of the numerous little bubbles generated in it, had not kept us from diſcerning the luſtre of the ſtone.

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colour than blue, aſſiſt me to gueſs, whether itſelf were ſincere or no. But finding the glaſs impervious to ſo faint a light, I then thought it fit to try, whether hard bodies would not by attrition increaſe the diamond's light, ſo as to become penetrable thereby: and accordingly when I rubbed the glaſs briſkly upon the ſtone, I found the light to be conſpicuous enough, and ſomewhat dyed in its paſſage; but found it not eaſy to give a name to the colour it exhibited.

LASTLY, To comply with the ſuſpicion I had upon the whole matter, that the chief manifeſt change wrought in the ſtone was by compreſſion of its parts, rather than incaleſcence; I took a piece of white tile well glazed, and if I preſſed the ſtone hard againſt it, it ſeemed, though I did not rub it to and fro, to ſhine at the ſides. And however it did both very manifeſtly and vigorouſly ſhine, if, whilſt I ſo preſſed it, I moved it any way upon the ſurface of the tile, though I did not make it draw a line of above a quarter of an inch long, or thereabouts, and though I made it not move to and fro, but only from one end of the ſhort line to the other, without any return or lateral motion. Nay, after it had been often rubbed, and ſuffered to loſe its light again, not only it ſeemed more eaſy to be excited than at the beginning of the night; but if I did preſs hard upon it with my finger, at the very inſtant that I drew it briſkly off, it would diſcloſe a very vivid but exceeding ſhort-lived ſplendor, not to call it a little coruſcation.* So that a Carteſian would ſcarce ſcruple to think, he had found in this ſtone no ſlight confirmation of his ingenious maſter's hypotheſis, touching the generation of light in ſublunary bodies, not ſenſibly hot.

A POSTSCRIPT, *annexed ſome hours after the* Obſervations *were written.*

SO † many particulars taken notice of in one night, may make this ſtone appear a kind of prodigy; and the rather, becauſe having tried, as I formerly noted, not only a fine artificial cryſtal, and ſome alſo that is natural, but a ruby and two diamonds, I did not find, that any of theſe diſcloſed the like glimmering of light: yet after all, perceiving by the hardneſs, and the teſtimony of a ſkilful goldſmith, that this was rather a natural than artificial ſtone; for fear leſt there might be ſome difference in the way of ſetting, or in the ſhape of the diamonds I made uſe of, neither of which was like this, a flat table-ſtone, I thought fit to make a further trial of my own diamonds, by ſuch a briſk and aſſiduous affriction, as might make amends for the diſadvantages above-mentioned, in caſe they were the cauſe of the unſucceſsfulneſs of the former attempts. And accordingly I found, that by this way I could eaſily bring a diamond I wore on my finger to diſcloſe a light, that was ſenſible enough, and continued ſo, though I covered it with ſpittle, and uſed ſome other trials about it. And this will much leſſen the wonder of all the formerly mentioned obſervations, by ſhewing, that the properties, that are ſo ſtrange, are not peculiar to one diamond, but may be found in others alſo, and, perhaps, in divers other hard and diaphanous ſtones. Yet I hope, that what this diſcovery takes away from the wonder of theſe obſervations, it will add to the inſtructiveneſs of them, by affording pregnant hints towards the inveſtigation of the nature of light.

* I after bethought myſelf of employing a way, which produced the deſired effect, both ſooner and better. For holding betwixt my fingers a ſteel bodkin, near the lower part of it, I preſſed the point hard againſt the ſurface of the diamond, and much more if I ſtruck the point againſt it, the coruſcation would be extremely ſudden, and very vivid, though very vaniſhing too: and this way, which commonly much ſurprized and pleaſed the ſpectators, ſeemed far more proper than the other, to ſhew, that preſſure alone, if forcible enough, though it were ſo ſudden and ſhort, that it could not well be ſuppoſed to give the ſtone any thing near a ſenſible degree of warmth, as may be ſuſpected of rubbing, yet 'tis ſufficient to generate a very vivid light

† We afterwards tried precious ſtones, as diamonds, rubies, ſaphires, and emeralds, *&c.* but found not any of them to ſhine, except ſome diamonds; and of theſe we were not, upon ſo little practice, able to foretel beforehand, which would be brought to ſhine, and which would not: for ſeveral very good diamonds either would not ſhine at all, or much leſs than others, that were far inferior to them. And yet thoſe ingenious men are miſtaken, that think a diamond muſt be foul and cloudy, as Mr. *Clayton*'s was, to be fit for ſhining; for as we could bring ſome ſuch to afford a glimmering light, ſo with ſome clear and excellent diamonds we could do the like. But none of thoſe many, that we tried of all kinds, were equal to the diamond, on which the obſervations were made, not only conſidering the degree of light it afforded, but the eaſineſs wherewith it was excited, and the comparatively great duration of its ſhining.

SOME

SOME

CONSIDERATIONS

TOUCHING THE

STYLE *of the* HOLY SCRIPTURES.

EXTRACTED

From ſeveral Parts of a DISCOURSE, concerning divers Particulars belonging to the BIBLE;

Written divers years ſince to a FRIEND.

TO THE

EARL of *ORRERY*,

One of the LORDS JUSTICES of the Kingdom of *Ireland*, LORD PRESIDENT of the Province of *Munſter*, &c.

My Deareſt Brother,

THAT ſacred book, which furniſhes our preachers both with their texts and a great part of their diſcourſes on them, being the ſubject, about which I am to entertain you, I preſume it will not much ſurprize you, if what I ſhall ſay, in repreſenting to you ſome conſiderations on that book, reliſh more of a ſermon than of a letter of compliment. And indeed it would ſo little become a perſon, that writes of my ſubject, and with my deſign, to ſtartle at the very begining ſuch readers, as he deſires to find or make devout, with any thing written in the wonted ſtrain of epiſtles dedicatory; and the nature of the treatiſe, to which this paper is premiſed, does allow ſo little of that, whereof cuſtom, on ſuch occaſions, is wont to challenge ſo much; that I ſhould let this book come forth undedicated, were it not that the motives, that induced me to addreſs it to you, are of ſuch a nature, that I hope, that meerly by a plain repreſentation of them I may comply with what makes me look upon this dedication as a duty, without departing from the ſerious deſign I propoſed to my ſelf in the dedicated book. Although then ſuch readers, as having peruſed your writings, ſhall caſt their eyes on mine, will, I fear, think it a bold preſumption in me to addreſs diſcourſes, concerning a ſtyle, to a perſon ſo much and ſo juſtly applauded for his; yet as ſeveral reaſons engage me to preſent you theſe thoughts, ſo the fear of paſſing for preſumptuous for ſo doing obliges me to mention ſome of thoſe reaſons. Whereof the firſt ſhall be, that your kindneſs for, and your reſemblance in many particulars to, *Theophilus*, makes me often fancy, that I am yet entertaining that rare perſon, when I write on the behalf of the ſcripture unto you. Who may alſo, I preſume, remember (which is my ſecond reaſon,) that when, ſeven or eight years ago, I ventured to ſhew you divers of theſe papers, with others (that I yet ſuppreſs) belonging to the ſame treatiſe, you were pleaſed to give me ſuch a permiſſion, that in caſe they ſhould ever be made publick, I might addreſs what I had written at your friend's deſire particularly to you, as I took for an engagement, if not a command. So that how unlike ſoever the following treatiſe is to that beſt of books it would recommend; yet ſince you have thus made the preſent addreſs a duty, I muſt elect rather to betray to you my weakneſſes, than not manifeſt my obedience. And to theſe I muſt ſubjoin this third conſideration, (more prevalent perhaps with me than both the former,) that (as a homely digger may ſhew a man a rich mine) whatever the book may be that I preſent you, that which I recommend to you is a matchleſs one; and will, if ſo diſcerning a reader ſhall bring as much aſſiduity as capacity to diſcover its prerogatives, appear ſo worthy of what I have ſaid of it, that I allow my ſelf a hope, the following conſiderations will prove ſo happy, as either to endear the ſcripture to you, or (by not appearing ſuch as ſo good a ſubject would ſuggeſt to a good pen,) invite you to ſubſtitute better in their rooms. And in either of theſe caſes I ſhall not have cauſe to repent of having written them; ſince they will prove ſerviceable either to the book or to the man, to whom I moſt deſire to be ſo. And this hope I muſt again own to be the chief inducement of my venturing to preſent a fragment of an unpoliſhed treatiſe to a perſon, that

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is wont to write ſuch as are ſo eloquent and accompliſhed in their kind. For though ſevere, and not incompetent, judges of compoſures of this nature have been pleaſed to give theſe papers no diſapproving character; yet ſince I preſent them to you, the chief thing I dare pretend to in them is only (as the ſinging rare ſongs ill is wont, by an unheeeded indignation, to engage the poſſeſſors of rare voices to make them admired,) by diſcloſing my zeal and inſufficiencies, to invite you to reſcue ſo excellent a theme as the ſcripture from ſo dull a pen as mine, by employing your happy one in its defence and celebration: or, (if your partiality ſhould make you place any value on ſo unfiniſhed a piece) to convince you how capable of rare thoughts my ſubject is, by its being able to furniſh ſo barren a brain as mine with acceptable ones. And certainly, your pen having no leſs ſerved your fame than either your ſword, or your employments (how high ſoever;) it could not but bring the ſcripture more than a few of the moſt witty and illuſtrious votaries, if that eloquence were employed to enamour them of that divine book, that hath made them ſo generally in love with your celebrated *Partheniſſa*. I will not repreſent to you ſo pious an exerciſe of your rethorick and muſe as a duty, for fear of leſſening the diſintereſtedneſs of the employment I recommend to you, by implying, that you cannot decline it without a fault. I ſhall rather invite your pen to prefer itſelf to, and grace religious ſubjects, by aſſuring you, that as there are none more worthy of your pen, ſo there are few pens more likely to ſucceed upon ſome of them than yours. Thoſe handſome eſſays your muſe hath charmed me with upon ſome parts of the bible have given me longings equally great and juſt, to ſee her, by a devotedneſs to ſuch heavenly themes, as happy in the choice of her ſubjects, as ſhe is wont to be in the embelliſhing of them; and to have her make that her chief employment, wherein it is beſt to do, what ſhe doth always, ſucceed well. And as with burning-glaſſes though we cannot make the ſun ſhine, yet when he doth vouchſafe us his heavenly beams, we can, with thoſe glaſſes, both increaſe light and heat, and carry and ſettle them here and there as we ſee cauſe: ſo though with wit and parts, their poſſeſſors could never have been able to engage God to ſend forth his light and his truth; yet now that revelation hath diſcloſed them, and now he hath been pleaſed to make them radiate in his heavenly word, men may, with knowledge and eloquence, happily recollect thoſe ſcattered divine beams, and uniting them in particular ſubjects, and kindling with them the topicks proper to warm and work on our affections, may powerfully illuſtrate truths, and enflame zeal. Towards the latter end of the enſuing papers you will find ſomething ſaid to perſuade our *Theophilus*; that the choiceſt poetical and rhetorical ornaments may, without injury to their luſtre, be employed about ſuch ſubjects as may be choſen in the ſcripture: but more and better things, to the ſame purpoſe, have ſince been ſaid by our ingenious friend Mr. *Cowley*, who not only has employed much eloquence to perſuade that truth in his preface to his poems, but has in one of them given a noble example, and conſequently a proof of it. I need not tell you, I mean his *Davideis*, a work and way of writing, which, ſince your muſe has already thought fit to celebrate, I hope ſhe will hereafter think fit to imitate. And this I wiſh the more earneſtly, becauſe it hath been obſerved, that ſecular perſons of quality (of whom I have elſewhere occaſion to name divers) are generally much ſucceſsfuller in writing of religion, (to gentlemen eſpecially,) than ſcholaſticks or men in orders; not only becauſe their ſtyle and way of writing is obſerved to have in it ſome pleaſing *Je ne ſçay quoy*, ſomething of eaſy, genuine and handſome, that's peculiar to it, (differing from regular eloquence, as a good mien doth from beauty) and reliſhes of the native gracefulneſs wont to attend on what they do or ſay; but becauſe their writings attract more readers by the authors conſpicuouſneſs, and make deeper impreſſions in them, by being ſuppoſed more diſintereſted, and looked upon, not as ſuggeſted by their profeſſion or ſelf-ends, but as the ſincere dictates of their unbridled ſouls. For my part, though I am not ſo happy as to be much concerned in all the precedent conſiderations, yet thoſe, that you will find, towards the end of the longeſt digreſſion in the following diſcourſe, have been ſo prevalent with me, that though ſome very fair and very perſuaſive perſons (whom perhaps I need not name to you) did, when I was writing the annexed treatiſe, labour to divert my pen to ſome more youthful and more faſhionable compoſures, by flattering me with a perſuaſion, that in thoſe attempts of that nature I had formerly occaſion to make, I was not altogether unlucky; yet I, that would bring my ſelf to prefer to a whole wood of bayes the leaſt ſprig of the tree of life, am inclined to think, that a Chriſtian may poſſibly find a higher ſatisfaction in perſuading men to pay praiſes to the ſcripture, than in receiving them from all the world beſides; and would think it more deſirable, (were the choice his) to diſcountenance prophane wit, than live unrivalled in the glory of it. And though, for my own particular, ſuch a temper be, I fear, more my aim than my attainment; yet when I write of ſacred ſubjects, I had rather a book of mine ſhould reſemble the moon, which, though ſhe be but ſmall, leſs elevated, and full of imperfections, lends yet an uſeful light to men, and produces here and there a motion that obeys a heavenly influence, than a ſtar of the firſt magnitude, which though more high, more vaſt, and more flawleſs, ſhines only bright enough to make it ſelf conſpicuous. Pardon me therefore, my deareſt brother, if my concern for religion and you have made me importunate in appearing ſo eagerly ſolicitous to ſee your applauded pen ſanctified by, and adorn the beſt of ſubjects: to engage you to which, if the enſuing diſcourſe may but be ſo fortunate as in any degree, or upon any ſcore, to contribute any thing, I ſhall either not eſteem it a trifle, or not regret the having

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ing written it. For it is not always ſo deſpicable a piece of ſervice as may be imagined, to endear, by particular conſiderations, an excellent book, (and how much more that incomparable book the ſcripture?) to a perſon capable of diſcovering and making uſe of the rare things it contains. To which purpoſe I might offer you divers more ſerious inſtances, but ſhall only at preſent (a little to divert you) take this occaſion to tell you, that *Ben. Johnſon*, paſſionately complaining to a learned acquaintance of mine, that a man of the long robe, whom his wit had raiſed to great dignities and power, had refuſed to grant him ſome very valuable thing he had begged of him, concluded with ſaying, with an upbraiding tone and geſture to my friend; *Why, the ungrateful wretch knows very well, that before he came to preferment, I was the man, that made him reliſh* Horace.

But to return to the following book, though I hope you do not think me ſo vain as to doubt, that it is ſuffered to come abroad with imperfection enough to need my excuſes and your pardon; yet ſince the treatiſe it ſelf is ſo unmeaſurably prolix (for a part of an eſſay,) it were unfit the addreſs of it ſhould be ſo too; and give your patience as great an exerciſe upon the ſcore of its quantity, as upon that of its quality. And therefore, referring you for what I might ſay of apologetical to what I ſay to the reader, I ſhall only add, that though, in Epiſtles Dedicatory, cuſtom hath made it a kind of rudeneſs not to expatiate in praiſes, and conclude with complements; and though what you have acted, and what you have written, might ſupply a perſon leſs concerned than I with matter for a panegyrical addreſs; yet ſince I told you, at the beginning of this letter, I ſhould rather preach than compliment in it; and ſince praiſes fit to be aſcribed to my Lord *Orrery* would be unfit to be aſcribed him by his brother; and ſince alſo it were ſcarce more uneaſy for me to make you any other than ſeeming complements, than it were preſumptuous to addreſs any at all to ſo great a maſter in the art; I ſhall both decline praiſes, which not to ſeem flatteries, where you are not known, would perhaps be thought detractions where you are; and venture to conclude this letter, as I have begun and continued it, without compliment, upon the ſcore of being without, if not above any,

My deareſt Brother,

Your moſt Affectionate Brother,

and moſt Faithful Humble Servant,

ROBERT BOYLE.

To the READER.

The author having with the following diſcourſe ſent to the publiſher a letter, which contains almoſt all the particulars, that would be requiſite to be taken notice of in a preface, it is thought fit to premiſe, inſtead of it, the letter it ſelf, as it was addreſſed to Mr. P. P. A. G. F. I. *(to favour whoſe modeſty, he is not now more openly named.)*

SIR,

YOU will perhaps think it ſtrange, that a perſon obſequious enough to thoſe he loves ſhould be able to hold out ſo long againſt the importunity of two ſuch powerful ſollicitors, as my willingneſs to own a veneration for the ſcripture, and my unwillingneſs to deny you any thing. But if you will give me leave to acquaint you with the conſiderations, that have hitherto diſſuaded me from the publication of the papers you preſs for, you will, I preſume, rather marvel at my reſolving at laſt to comply with your deſires, than that I have been ſomewhat long conteſting, before I could take up ſo oppoſed a reſolution. Firſt then, the treatiſe, of which the papers you deſire make a part, was written nine or ten years ago, when my green youth made me very unripe for a taſk of that nature; whoſe difficulty requires, as well as its worth deſerves, that it ſhould be handled by a perſon, in whom nature, education, and time have happily matched a ſenile maturity of judgment with a youthful vigour of fancy. Next, the diſcourſe I have mentioned being written to a private friend, who put me upon that taſk, I not only had a theme of another's chooſing impoſed upon me, for which he was pleaſed to think me much more fit than I had reaſon to think my ſelf, but was by the freedom allowable among friends tempted to vent and expreſs my thoughts with more negligence, than were proper to be made uſe of in a ſolemn diſcourſe intended for publick view. The contrary of which were yet very requiſite for a perſon, who though he have, by I know not what unhappy fate, been caſt upon the learning divers languages, has yet too great a concern for the knowledge of things to be a diligent or ſollicitous conſiderer of words; and ſo was more fit to write almoſt of any thing, than of a ſtyle, or of matters rhetorical. Beſides, that my Eſſay touching the Scripture having not been all written in one country, but partly in *England*, partly in another kingdom, and partly too on ſhipboard, it were ſtrange, if in what I writ, there did not appear much of unevenneſs, and if it did not betray the unleiſuredneſs, and reliſh of the unſettledneſs of the wandering author, who, by thus rambling, was reduced, for want of a library, to comply with the requeſt of his friend, who was more deſirous to receive from the author apples and pears growing in his

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own orchard, than oranges and lemons fetched from foreign parts: whereby I was condemned not to enrich my diſcourſe with what I might have borrowed, of real and valuable, from the eloquent compoſures of more happy pens. But theſe, Sir, are not all the determents, that oppoſed my obeying you; for beſides theſe diſadvantages, with which the diſcourſe itſelf was written, that part of it you demand muſt appear with a peculiar as well as great diſadvantage: for in an intire and continued diſcourſe, the ſeveral parts, that compoſe it, do mutually afford light and confirmation to each other. And therefore, though whatſoever I here preſent you, touching the ſtyle of the ſcripture, had been written altogether in ſome one place of the diſcourſe, whereof it makes a part; yet I could not diſmember it from the reſt, without a great deal of injury, as well to it as to the reſt of the treatiſe. But this is not the worſt of my caſe; for though I did, in one part of my eſſay of the ſcripture, more profeſſedly apply myſelf to the conſideration of its ſtyle; yet, becauſe divers things were interwoven even in the diſtinct part, which were not ſo fit for publick view; and becauſe that in divers of the other parts of my eſſay I had here and there, frequently enough, occaſion to ſay ſomething of the ſame theme, I have been obliged, that I might obey you, not only to diſmember, but to mangle the treatiſe you peruſed, cutting out with a pair of ſciſſars here a whole ſide, there half, and in another place perhaps, a quarter of one; as I found, in the other parts of my diſcourſe, longer or ſhorter paſſages, that appeared to relate to the ſtyle of the ſcripture, that I might give you at once all thoſe parts of my eſſay, which ſeemed to concern that ſubject. And though I have, here and there, by dictating to an amanuenſis, inſerted ſome lines or words, to make the looſe papers leſs incoherent, where I thought it eaſy to be done; yet in many others I have only prefixed a ſhort black line to the incoherent paſſages, if I found they could not be connected with thoſe, whereunto I have joined them, without ſuch circumlocution, as either the narrowneſs of the paper would not permit, or my preſent diſtractions (which you know are not a few,) and the weakneſs of my eyes, would not allow of. For, to compleat my unfitneſs to obey you with any thing of accurateneſs, I muſt, to obey you at all, do it, both when I have other compoſures in the preſs, and when the diſtemper in my eyes makes me ſo far from daring to tranſcribe the papers I ſend you, that I might alter them, according to the exigency of your deſign in them, that I durſt not ſo much as read them over, but with another's eyes. To which I muſt add, that, beſides all theſe diſadvantages I have already mentioned, I cannot but foretel, that the following diſcourſe may prove obnoxious to the cenſures of differing ſort of readers, and particularly to thoſe of courtiers, for too neglected, and thoſe of critics, for too ſpruce a dreſs. By all which, I preſume, you will be eaſily induced to believe, with me, that I cannot expoſe the papers you deſire ſo much to their diſadvantage and my own, without ſome exerciſe of ſelf-denial: ſince, without needing much foreſight, I may well apprehend, that I ſhall hereby hazard the loſs of the moſt part of whatever little reputation, in this nature, any of my former moral or devout compoſures may, among favourable readers, have procured me.

But, by this time, Sir, I ſuppoſe not only, that you have left wondering at my making ſome difficulty to put the annexed papers into your hands, but that I owe you, and my other friends, an account, why I now conſent to a compliance with deſires, which ſuch powerful conſiderations would diſſuade my aſſenting to.

My firſt inducement then to what I do, is the favourable character, that you and ſome other very competent judges have been pleaſed to give me of theſe papers; and eſpecially your thereupon preſſing their publication upon me as a duty, whereto I ſtand obliged, to thoſe many readers, whom you would have me think likely to be benefited thereby. For in ſuch caſes, where knowing and ſober perſons think there is a great probability of a diſcourſe's doing good, it is not impoſſible, but that an unwillingneſs to have it publiſhed may not ſo much proceed out of modeſty, as from ſome ſecret pride, almoſt as unjuſtifiable, as if a phyſician ſhould refuſe to come abroad upon an urgent occaſion, becauſe he has not his beſt clothes on, or is not carefully dreſſed. And therefore, when I incline to make, with you, a caſe of conſcience of the matter, I think myſelf obliged, whatever my private apprehenſions may be of the ſucceſs, to do my duty, and leave events to the wiſe and ſovereign diſpoſer of them. It is not, that I have the vanity to expect, that I ſhould convert obſtinate and reſolved cavillers, nor much inſtruct the great clerks; but ſince I have not yet met with ſuch a diſcourſe, as I intended mine to be; and ſince the greater part of the things I have written in it will not, perhaps, be elſewhere met with; I hope, that what I have ſaid may not be uſeleſs to thoſe, who have conſidered the ſubject, I treat of, leſs attentively than I have done, and may, if not procure a veneration for the ſcripture in thoſe that are altogether indiſpoſed to it, yet at leaſt increaſe or confirm it in thoſe, that have already entertained it; and furniſh ſuch devout perſons with ſomething to alledge on the ſcripture's behalf, who are better furniſhed with affections than with arguments for it. And I the leſs ſcruple to allow myſelf ſuch a hope, becauſe you have been pleaſed to make, not only to me, but to others, ſuch a mention of the following papers, that after your preference of them to the other pieces of devotion, you have yet ſeen of mine (without excepting that diſcourſe of *Seraphick Love*, which yet has had the luck to be ſo favourably entertained by readers of all ſorts) I ſhall confeſs to you, that as ſome of them do now appear very much diſlocated and mangled, ſo others were penned with more care, than any other of my writings about matters theological. And indeed I conceived my ſelf obliged,

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obliged, in point of gratitude as well as duty, to ſpeak as advantageouſly as I could of the ſcripture; becauſe, if I may without vanity make ſuch an acknowledgement, I am ſenſible I have been benefited by it, and might have been much more ſo, if I had been as diſpoſed to learn, as the matchleſs book is qualified to teach. And I confeſs to you alſo, that ſince the phyſiological writings I have been induced to publiſh of late, and the ſort of ſtudies, to which (for reaſons to be told you at a fitter opportunity) I ſeem, at preſent, to be wholly addicted to, make many look upon me as a naturaliſt; and ſince ſome perſons, as well philoſophers as phyſicians, have either faultily, or at leaſt indiſcreetly, given many men occaſion to think, that thoſe, that being ſpeculatively ſtudious of nature's myſteries, depart, as I often do, from the vulgar peripatetick philoſophy, and eſpecially if they ſeem to favour that, which explicates the phænomena of nature by atoms, are inclined to atheiſm, or at leaſt to an unconcernedneſs for any particular religion: Since, I ſay, theſe things are ſo, I was not unwilling to lay hold of this opportunity, to give a publick teſtimony, whereby ſuch as do not know me may be ſatisfied, (for I preſume, all that do know me, are ſo,) that, if I be a naturaliſt, it is poſſible to be ſo without being an atheiſt, or of kin to it; and that the ſtudy of the works of nature has not made me either diſbelieve the author of them, or deny his providence, or ſo much as diſeſteem his word, which deſerves our reſpect upon ſeveral accounts, and eſpecially that of its being the grand inſtrument of conveying to us the truths and myſteries of the Chriſtian religion; my embracing of which I know not why I ſhould be aſhamed to own, ſince I think I can, to a competent and unprepoſſeſſed judge, give a rational account of my ſo doing.

To all this, I might ſubjoin ſome apologies, which might perhaps ſerve to prevent, or withdraw, the cenſures of ſome ſorts of readers.

For to critics and philologers I could repreſent, partly, that I have not a little impoveriſhed my diſcourſe, by making uſe of books, to ſhun the repetition of what I found obvious already; partly, that when I wrote the eſſay, of which the enſuing treatiſe is a piece, I had thoughts of annexing it to annotations, wherein I hoped to illuſtrate, and by particular inſtances to exemplify, divers of thoſe things, which ſhould appear to require it, or which elſe the readers might ſuſpect I have ſlightly conſidered, becauſe I ſeem to make but a tranſient mention of them; and partly, too, that I ignored not the ſtricter interpretations given by modern critics to divers texts by me alledged; but that (not having opportunity to criticize) I was content to uſe them in their received, or obvious ſenſe; and have ſometimes employed them but by way of alluſion, or as arguments *ad hominem* (wherein ſome of my readers are like to acquieſce, though I do not) and ſometimes rather uſed them to expreſs, than prove my thoughts. And, indeed, in theſe popular diſcourſes, which are not written for, nor to be examined as regular diſputations, men uſe not ſo much to look whether every thing be a ſtrict truth, as whether it be proper to perſuade, or impreſs the truths they would inculcate; and eſpecially in compoſures of the nature of this of mine, men have been rarely cenſured for being ſometimes even indulgent to the exigences of their themes. Thoſe, that require more of method than they will here find, may be advertiſed, that much of this ſcribble being deſigned to ſerve particular acquaintances of mine, it was fit it ſhould inſiſt on thoſe points they were concerned in; and that (conſequently) much of the ſeeming deſultorineſs of my method, and frequency of my rambling excurſions, have been but intentional and charitable digreſſions out of my way, to bring ſome wandering friends into theirs, and may cloſely enough purſue my intentions, even when they ſeem moſt to deviate from my theme And as for the longer excurſions, which either you, or other judicious friends, would needs have me leave here and there, I have, for the eaſe of my peruſers, annexed to them ſome marks, whereby they may be taken notice of, to be digreſſions; that as I ſubmit to their judgment, who think they may be uſeful to ſome readers, ſo I may comply with my own unwillingneſs to let them be troubleſome to others; who by this means have an opportunity to paſs by, if they pleaſe, ſuch, as they ſhall not expect to find themſelves, (either upon their own ſcore, or that of their acquaintances) concerned in. To thoſe of the wits, who happening to be diſregarders of the ſcripture, may find themſelves upon that account uſed here with any ſhew of ſlighting or aſperity, I may add to what I have already ſaid in the papers themſelves, that it hath been, but as we pinch, and caſt cold water on the faces of perſons in a ſwoon, to bring them out of it to themſelves again; I having done it with as harmleſs intentions, as thoſe of the angel (mentioned in in the *Acts*) when he ſtruck *Peter* on the ſide, not to hurt him, but to awake him, lead him the way out of the priſon he was bound in, and reſcue from imminent death. And if that will not ſatisfy ſome of the leaſt judicious, or the moſt deſperate, (for others I expect to find better affected or more moderate) I am willing to leave the intelligent and pious to judge between us; aſſuring thoſe, that are ſo much more jealous of their own honour than of God's, that as I writ to reclaim them, not to deprive them of the repute of wits, or ſhare it with them, ſo I ſhall not overmuch deplore the being by them denied a title, to which I have as little pretenſion as right. And (to diſpatch) I might add, that orators may not unjuſtly bear with ſome rudeneſſes in the ſtyle of a perſon, that profeſſes not rhetorick, and writes of a ſubject, that needs few of her ornaments, and rejects many as indecencies misbecoming its majeſty: and that ſeverer divines may ſafely pardon ſome ſmoothneſs in a diſcourſe, written chiefly for gentlemen, who would ſcarce be fond of truth in every dreſs, by a gentleman, who feared it might misbecome a perſon of his youth and

Acts xii. 7, &c.

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and quality ſtudiouſly to decline a faſhionable ſtyle. And if any divine would cenſure me for intruding upon his profeſſion, and handling my ſubject leſs ſkilfully than he would have done; I will not urge, that to write well on this ſubject is a taſk, which he that ſhall try, will perhaps find far leſs eaſy than one would imagine; but I ſhall rather tell him, that I hope I may obtain his pardon, by aſſuring him, that I ſhall be as little angry to be rectified in my miſtakes, as to be ſhown the way when I am out of it, and as little troubled to have this diſcourſe, that but ſkirmiſhes with lazineſs and prophaneneſs, ſurpaſſed by another on the ſame ſubject, as to ſee another embracer of the ſame quarrel come in with a freſh regiment, to aſſiſt me againſt a formidable enemy, in a conflict I were engaged in but with a troop, or bring cannon againſt a fortreſs I had but ſakers to batter with. Yes, I ſhall be glad, if my dim ſhort-lived match but ſerve to light another's brighter torch; and ſhall think it a happineſs to have contributed, though but thus occaſionally, towards the elucidation, or ſplendour of the ſcripture. And conſonantly to this temper, I would beſeech any reader, that may ſo much want learning as to need ſuch a requeſt, not to meaſure what can be ſaid in the defence and celebration of the ſcripture's ſtyle, by what hath in the following diſcourſe been traced by the callow pen of a travelling layman. For I profeſs ingenuouſly, that there can as little be an unwelcomer as an unjuſter compliment placed upon me, than to miſtake any thing that I am able to ſay, and much leſs what I have ſaid, for the beſt that can be ſaid upon ſuch a ſubject. Nor is it my leaſt encouragement to conſent to the publication of ſuch incompleat writings, that the conſiderations already intimated will probably keep my readers from doing the ſcripture and their own judgment ſo great an injury.

But I ſee I have ſo far tranſgreſſed the bounds of a letter, that if I add any thing more of apology, it muſt be for having been ſo prolix already. Wherefore there ſcarce remains any thing for me, but to mind you, that ſince your perſuaſions have ſo much contributed to my expoſing the following tract, incompleat as it is, your own credit is ſomewhat concerned in it as well as mine. And therefore I hope you will have a care, that there be no faults of the printer added to thoſe of the author, which do ſo little need additional blemiſhes; and eſpecially that there paſs no miſtakes of the punctation. For in ſuch compoſures as this, if the ſtops be omitted, or miſplaced, it does not only leſſen the gracefulneſs of what is ſaid, but oftentimes quite ſpoil the ſenſe. And if by this care of yours (which your affection, both for the ſubject, and the writer makes me confident of) and by the authority of your approbation, I find theſe imperfect conſiderations to be ſo favourably received as to deſerve another edition; it will perhaps invite me to put them forth enlarged, and recruited with what I may meet with pertinent to this ſubject in ſuch other papers of mine concerning the ſcripture, as I had not yet the conveniency to get into mine own hands and look over. However, though I pretend not here to anſwer all objections againſt the ſtyle of the ſcripture; yet, as I hope, I have been ſo happy as to anſwer ſome of them, and weaken moſt of the reſt; ſo if others, that are more able, will but employ themſelves as earneſtly in ſo uſeful a work, there is great hope, that ſome anſwering this objection, another that, and a third another, they may at length be all of them ſatisfactorily replied to. And in the mean time I ſhall think my labour richly recompenſed, if they either procure or eſtabliſh a veneration for the ſcripture in any of my readers; or do at leaſt encourage thoſe, that are qualified for a far more proſperous making ſuch an attempt, to undertake it, by ſhowing thoſe of them that know me, what were eaſy for them to do, whilſt they ſee what has been done even by me; whom ſure they will not think to be half ſo much an orator, as I hope ſo uneaſy a proof of his obedience will make you think him,

Sir, Your Affectionate Friend

and humble Servant,

ROBERT BOYLE.

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SOME

CONSIDERATIONS

TOUCHING THE

STYLE *of the* HOLY SCRIPTURES.

THESE things, dear *Theophilus*, being thus diſpatched, I ſuppoſe we may now ſeaſonably proceed to conſider the ſtyle of the ſcripture: a ſubject, that will as well require as deſerve ſome time and much attention; in regard that divers witty men, who freely acknowledge the authority of the ſcripture, take exceptions at its ſtyle, and by thoſe and their own reputation divert many from ſtudying, or ſo much as peruſing, thoſe ſacred writings; thereby at once giving men injurious and irreverent thoughts of it, and diverting them from allowing the ſcripture the beſt way of juſtifying it ſelf, and diſabuſing them. Than which ſcarce any thing can be more prejudical to a book, that needs but to be ſufficiently underſtood to be highly venerated; the writings theſe men criminate, and would keep others from reading, being like that honey, which *Saul*'s raſh adjuration with-held the Iſraelites from eating, which being taſted, not only gratified the taſte, but enlightned the eyes.

1 Sam. xiv. *ver.* 27, 29.

Now theſe allegations againſt the ſcripture we are to examine being but too various, it will be requiſite for us to conſider the ſtyle of it, not in the ſtricter acceptation, wherein an author's ſtyle is wont to ſignify the choice and diſpoſition of his words, but in that larger ſenſe, wherein the word ſtyle comprehends not only the phraſeology, the tropes and figures made uſe of by a writer, but his method, his lofty or humbler character (as orators ſpeak) his pathetical or languid, his cloſe or incoherent way of writing; and in a word, almoſt all the whole manner of an author's expreſſing himſelf.

WHEREFORE, though the title of an eſſay prefixed to this treatiſe will, I preſume, invite you to expect from me rather ſome looſe conſiderations than any full and methodical diſcourſe concerning the ſtyle of the ſcripture; yet I hope you will not think it ſtrange, if ſo comprehenſive a theme make this part of the eſſay diſproportionate to the others; eſpecially ſince the nature of your commands, and that of my deſign, oblige me to interweave ſome other things with thoſe that more directly regard the ſtyle of the ſcripture, and particularly to lay hold on all opportunities I can diſcreetly take, to invite you to ſtudy much, and highly to eſteem a book, which there is no danger you can too much ſtudy, or eſteem too highly.

IT has been a common ſaying among the ancients, that even *Jupiter* could not pleaſe all. But by the objections I meet with againſt the ſcripture, I find, that the true God himſelf is not free from the imputation of his audacious creatures, who impiouſly preſume to quarrel as well with his revelations as his providence, and expreſs no more reverence to what he hath dictated than to what he doth. For not now to mention what is by atheiſts and antiſcripturiſts alledged to overthrow the truth and authority of the ſcripture, (becauſe it is not here, but elſewhere, that we are to deal with that ſort of men) even by ſome of thoſe, that acknowledge both, (for with ſuch only we have now to reaſon,) there are I know not how many faults found with the ſtyle of the ſcripture. For ſome of them are pleaſed to ſay, that book is too obſcure; others, that it is immethodical; others, that it is contradictory to itſelf; others, that the neighbouring parts of it are incoherent; others, that it is unadorned; others, that it is flat and unaffecting; others, that it abounds with things, that are either trival or impertinent, and alſo with uſeleſs repetitions. And indeed ſo many and ſo various are the faults and imperfections imputed by theſe men to the ſcripture, that my wonder at them would be almoſt as great as is my trouble, if I did not conſider, how much it is the intereſt of the great adverſary of mankind, and eſpecially of (that choiceſt part of it) the church, to depreciate compoſures, that if duly reverenced would prove ſo deſtructive to his kingdom and deſigns; and if I did not alſo remember, that (ſuch is the querulous and exceptious nature of men) it was *Cicero* himſelf that obſerved, *Vitari non poſſe reprehenſionem, niſi nihil ſcribendo.* But as poets and aſtronomers have fancied, among the celeſtial lights, that adorn the firmament, bears, bulls, goats, dogs, ſcorpions, and other beaſts; ſo our adverſaries impute I know not what imaginary deformities to a book, ennobled by its author with many celeſtious lights, fit to inſtruct the world, and diſcover to them the ways of truth and bleſſedneſs. Although, I ſay, this be ſo, yet ſince the miſ-repreſentation made by theſe men of the bible is not inferiour to that made by poets and coſmographers of the firmament; I hope you will be as little deterred by the moſt diſparaging imputations from ſtudying the ſcripture, as pilots are by the name of *bear* given to the moſt northern conſtellation, from having their eyes upon the pole-ſtar, and ſteering their courſes by it.

AND ſince you will eaſily believe, that a perſon ſo averſe from wrangling as I is not like to make the diſputing with theſe cenſures of the

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the ſcripture-ſtyle, any further his deſign, than as the invalidating their objections conduces to the reputation of that ſacred book; I preſume you will not think it at all impertinent, if oftentimes I intermix with thoſe things, that more directly regard ſuch objections, other things, that ſeem to tend rather to celebrate than vindicate the ſcripture. For in ſo doing, I hope I ſhall not alone conſiderably, though not perhaps ſo directly, ſtrengthen my anſwers, by ſhewing that we juſtly aſcribe to the ſcripture qualities quite oppoſite to the imperfections imputed to it; but I ſhall perfectly comply with my main deſign, which I here declare, once for all, is but to engage you to ſtudy and value the ſcripture, and therefore obliges me to anſwer objections only ſo far forth, as they may look like arguments to diſſuade you from prizing and ſtudying it. And becauſe I find not, that the objections to be conſidered have any great coherence with, or dependence on each other, I ſhall not ſcruple to mention them, and my reflections on them, in no other order, than that wherein they ſhall chance to occur to my thoughts whilſt I am writing.

OF the conſiderations then, that I am to lay before you, there are three or four, which are of a more general nature; and therefore being ſuch as may each of them be pertinently employed againſt ſeveral of the exceptions taken at the ſcripture's ſtyle, it will not be inconvenient to mention them before the reſt.

AND, in the firſt place, it ſhould be conſidered, that thoſe cavillers at the ſtyle of the ſcripture, that you, and I have hitherto met with, do (for want of ſkill in the original) eſpecially in the Hebrew, judge of it by the tranſlations, wherein alone they read it. Now ſcarce any but a linguiſt will imagine, how much a book may loſe of its elegancy, by being read in another tongue than that it was written in; eſpecially if the languages, from which, and into which, the verſion is made, be ſo very differing, as are thoſe of the eaſtern and theſe weſtern parts of the world. But of this I foreſee an occaſion of ſaying ſomething hereafter; yet at preſent I muſt obſerve to you, that the ſtyle of the ſcripture is much more diſadvantaged, than that of other books, by being judged of by tranſlations. For the religious and juſt veneration, that the interpreters of the bible have had for that ſacred book, has made them, in moſt places, render the Hebrew and Greek paſſages ſo ſcrupulouſly word for word, that for fear of not keeping cloſe enough to the ſenſe, they uſually care not how much they loſe of the eloquence of the paſſages they tranſlate. So that, whereas in thoſe verſions of other books, that are made by good linguiſts, the interpreters are wont to take the liberty to recede from the author's words, and alſo ſubſtitute other phraſes inſtead of his, that they may expreſs his meaning, without injuring his reputation; in tranſlating the Old Teſtament, interpreters have not put Hebrew phraſes into Latin or Engliſh phraſes, but only into Latin or Engliſh words; and have too often beſides, by not ſufficiently underſtanding, or at leaſt conſidering, the various ſignifications of words, particles, and tenſes in the holy tongue, made many things appear leſs coherent, or leſs rational, or leſs conſiderable, which, by a more free and ſkilful rendring of the original, would not be blemiſhed by any appearance of ſuch imperfection. And though this fault of interpreters be pardonable enough in them, as carrying much of its excuſe in its cauſe; yet it cannot but much derogate from the ſcripture, to appear with peculiar diſadvantages, beſides thoſe many, that are common to almoſt all books, by being tranſlated.

FOR whereas the figures of rhetoric are wont, by orators, to be reduced to two comprehenſive ſorts; and one of thoſe does ſo depend upon the ſound and placing of the words (whence the Greek rhetoricians call ſuch figures σχήματα λέξεως) that, if they be altered, though the ſenſe be retained, the figure may vaniſh; this ſort of figures, I ſay, which comprizes thoſe that orators call *Epanados*, *Antanaclaſis*, and a multitude of others, are wont to be loſt in ſuch literal tranſlations as are ours of the bible, as I could eaſily ſhow by many inſtances, if I thought it requiſite.

BESIDES, there are in Hebrew, as in other languages, certain appropriated graces, and a peculiar emphaſis belonging to ſome expreſſions, which muſt neceſſarily be impaired by any tranſlation, and are but too often quite loſt in thoſe, that adhere too ſcrupulouſly to the words of the original. And, as in a lovely face, though a painter may well enough expreſs the cheeks, and the noſe, and lips; yet there is often ſomething of ſplendour and vivacity in the eyes, which no pencil can reach to equal: ſo, in ſome choice compoſures, though a ſkilful interpreter may happily enough render into his own language a great part of what he tranſlates, yet there may well be ſome ſhining paſſages, ſome ſparkling and emphatical expreſſions, that he cannot poſſibly repreſent to the life. And this conſideration is more applicable to the bible and its tranſlations, than to other books, for two particular reaſons.

FOR firſt, it is more difficult to tranſlate the Hebrew of the Old Teſtament, than if that book were written in Syriack, or Arabick, or ſome ſuch other eaſtern language. Not that the holy tongue is much more difficult to be learned than others; but becauſe in the other learned tongues, we know there are commonly variety of books extant, whereby we may learn the various ſignifications of the words and phraſes; whereas the pure Hebrew being unhappily loſt, except ſo much of it as remains in the Old Teſtament, out of whoſe books alone we can but very imperfectly frame a dictionary and a language, there are many words, eſpecially the ἅπαξ λεγόμενα, and thoſe that occur but ſeldom, of which we know but that one ſignification, or thoſe few acceptions, wherein we find it uſed in thoſe texts, that we think we clearly underſtand. Whereas, if we conſider the nature of the primitive tongue, whoſe words being not numerous, are moſt of them equivocal enough, and do many of them

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them abound with ſtrangely different meanings; and if we conſider too, how likely it is, that the numerous conqueſts of *David*, and the wiſdom, proſperity, fleets, and various commerces of his ſon *Solomon*, did both enrich and ſpread the Hebrew language, it cannot but ſeem very probable, that the ſame word or phraſe may have had divers others ſignifications, than interpreters have taken notice of, or we are now aware of: ſince we find in the Chaldee, Syriack, Arabick, and other eaſtern tongues, that the Hebrew words and phraſes (a little varied, according to the nature of thoſe dialects) have other, and oftentimes, very different ſignifications, beſides thoſe, that the modern interpreters of the bible have aſcribed to them. I ſay, the modern, becauſe the ancient verſions before, or not long after our Saviour's time, and eſpecially that which we vulgarly call the Septuagint's, do frequently favour our conjecture, by rendring Hebrew words and phraſes to ſenſes very diſtant from thoſe more received ſignifications in our texts; when there appears no other ſo probable reaſon of their ſo rendring them, as their believing them capable of ſignifications differing enough from thoſe, to which our later interpreters have thought fit to confine themſelves. The uſe, that I would make of this conſideration, may eaſily be conjectured, namely, that it is probable, that many of thoſe texts, whoſe expreſſions, as they are rendred in our tranſlations, ſeem flat, or improper, or incoherent with the context, would appear much otherwiſe, if we were acquainted with all the ſignifications of words and phraſes, that were known in the times, when the Hebrew language flouriſhed, and the ſacred books were written; it being very likely, that among thoſe various ſignifications, ſome one or other would afford a better ſenſe, and a more ſignificant and ſinewy expreſſion, than we meet with in our tranſlations; and perhaps would make ſuch paſſages, as ſeem flat or uncouth, appear eloquent and emphatical. Whilſt I am writing this, our Engliſh tongue preſents to my thoughts an example, which may ſeem to illuſtrate much of the foregoing conſideration: and it is this; that though, as one would eaſily believe, there are but a few forms of ſpeaking, which relate to the birth of infants, yet there are five or ſix expreſſions concerning that one affair, wherein very peculiar and unwonted notions belong to the words and phraſes: for, if I ſay, that ſuch a woman has looked every hour theſe ten days; that yeſterday ſhe cried out; that ſhe had a quick and eaſy labour; that laſt night ſhe was brought-to-bed; that now ſhe lies-in; and, that it is fit we ſhould remember the lady in the ſtraw: if, I ſay, I make uſe of any or all of theſe expreſſions, an Engliſhman would readily underſtand me; but if I ſhould literally, and word for word, tranſlate them, I ſay, not into Greek or Hebrew, but into the languages of our neighbour-nations, French or Italian, men would not underſtand what I mean. And if a diſcourſe, wherein they were employed, were tranſlated by an interpreter only acquainted with the genuine and more obvious ſignification of the Engliſh word, it would, in ſuch paſſages, appear very diſadvantageouſly, and perhaps be thought impertinent, or non-ſenſical, to a French or Italian reader.

BUT this is not all; for I conſider in the ſecond place, that not only we have loſt divers of the ſignifications of many of the Hebrew words and phraſes, but that we have alſo loſt the means of acquainting ourſelves with a multitude of particulars relating to the topography, hiſtory, rites, opinions, faſhions, cuſtoms, *&c.* of the antient Jews and neighbouring nations, without the knowledge of which we cannot, in the peruſing of books of ſuch antiquity, as thoſe of the Old Teſtament, and written by and (principally) for Jews; we cannot, I ſay, but loſe very much of that eſteem, delight, and reliſh, with which we ſhould read very many paſſages, if we diſcerned the references and alluſions, that are made in them to thoſe ſtories, proverbs, opinions, *&c.* to which ſuch paſſages may well be ſuppoſed to relate. And this conjecture will not, I preſume, appear irrational, if you but conſider, how many of the handſomeſt paſſages in *Juvenal*, *Perſius*, *Martial*, and divers other Latin writers, (not to mention *Heſiod*, *Muſæus*, or other antienter Greeks) are loſt to ſuch readers, as are unacquainted with the Roman cuſtoms, government, and ſtory; nay, or are not ſufficiently informed of a great many particular circumſtances, relating to the condition of thoſe times, and of divers particular perſons pointed at in thoſe poems. And therefore it is, that the latter critics have been fain to write comments, or at leaſt notes, upon every page, and in ſome pages upon almoſt every line of thoſe books, to enable the reader to diſcern the eloquence, and reliſh the wit of the author. And if ſuch dilucidations be neceſſary to make us value writings, that treat of familiar and ſecular affairs, and were written in an European language, and in times and countries much nearer to ours; how much do you think we muſt loſe of the elegancy of the book of *Job*, the Pſalms of *David*, the Song of *Solomon*, and other ſacred compoſures, which not only treat oftentimes of ſublime and ſupernatural myſteries, but were written in very remote regions ſo many ages ago, amidſt circumſtances, to moſt of which we cannot but be great ſtrangers? And thus much for my firſt general conſideration.

MY ſecond is this, That we ſhould carefully diſtinguiſh betwixt what the ſcripture itſelf ſays, and what is only ſaid in the ſcripture. For we muſt not look upon the bible as an oration of God to men, or as a body of laws, like our Engliſh ſtatute-book, wherein it is the legiſlator, that all the way ſpeaks to the people; but as a collection of compoſures of very differing ſorts, and written at very diſtant times; and of ſuch compoſures, that though the holy men of God (as St. *Peter* calls them) were acted by the Holy Spirit, who both excited and aſſiſted them in penning the ſcripture, yet there are many others, beſides the author and the penmen, introduced ſpeaking there. For beſides

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the books of *Joſhua*, *Judges*, *Samuel*, *Kings*, *Chronicles*, the four evangeliſts, the *Acts of the Apoſtles*, and other parts of ſcripture that are evidently hiſtorical, and wont to be ſo called; there are, in the other books, many paſſages, that deſerve the ſame name, and many others, wherein, though they be not meer narratives of things done, many ſayings and expreſſions are recorded, that either belong not to the author of the ſcripture, or muſt be looked upon as ſuch, wherein his ſecretaries perſonate others. So that, in a conſiderable part of the ſcripture, not only prophets, and kings, and prieſts being introduced ſpeaking, but ſoldiers, ſhepherds, and women, and ſuch other ſorts of perſons, from whom witty or eloquent things are not (eſpecially when they ſpeak *ex tempore*) to be expected, it would be very injurious to impute to the ſcripture any want of eloquence, that may be noted in the expreſſions of others, than its author. For though, not only in romances, but in many of thoſe that paſs for true hiſtories, the ſuppoſed ſpeakers may be obſerved to talk as well as the hiſtorian; yet that is, but either becauſe the men ſo introduced were ambaſſadors, orators, generals, or other eminent men for parts, as well as employments; or becauſe the hiſtorian does, as it often happens, give himſelf the liberty to make ſpeeches for them, and does not ſet down indeed what they ſaid, but what he thought fit that ſuch perſons, on ſuch occaſions, ſhould have ſaid. Whereas the pen-men of the ſcripture, as one of them truly profeſſes, having not followed cunningly deviſed fables in what they have written, have faithfully ſet down the ſayings, as well as actions, they record, without making them rather congruous to the conditions of the ſpeakers, than to the laws of truth.

NOR is it only the ſtyle of very many paſſages of ſcripture, that may be juſtified by our ſecond conſideration; but, with the ſame diſtinction well applied; we may ſilence ſome of their malicious cavils, who accuſe the ſcripture of teaching vice by the ungodly ſayings and examples, that are here and there to be met with in it. But, as the Apoſtle ſaid, that *they are not all Iſrael, that are of Iſrael*; ſo we may ſay, that is not ſcripture, that is in the ſcripture: for many wicked perſons, and their perverter Satan, are there introduced, whoſe ſayings the Holy Ghoſt doth not adopt, but barely regiſters; nor does the ſcripture affirm, that what they ſaid was true, but that it is true they ſaid it. And if I had not reduced ſome of thoſe cavillers to confeſs, that they never did themſelves read thoſe pieces of the bible, at ſome of whoſe paſſages they cavil, I ſhould much more admire than I do, to find them father, as confidently as they do all they hear cited from it, upon the enditer of it; as if the devil's ſpeeches were not recorded there, and as if it were requiſite to make a hiſtory divinely inſpired, that all the blaſphemies and crimes it regiſters ſhould be ſo too. As for the ills recorded in the ſcripture, beſides that wicked perſons were neceſſary to exerciſe God's children, and illuſtrate his providence; and, beſides the allegations commonly made on that ſubject, we may conſider, that there being many things to be declined, as well as practiſed, 'twas fit we ſhould be taught as well what to avoid, as what to imitate; and the known rocks and ſhelves do as well guide the ſeamen, as the pole-ſtar. Now, as we could not be armed againſt the tempter's methods, if we ignored them, ſo could we never ſafelier nor better learn them, than in his book, who can alone diſcover the wiles, and fathom the *depths of Satan*, and track him through all his windings, and (otherwiſe untraceable) labyrinths; and in that book, where the antidote is exhibited with the poiſon, and either mens defeat or victory may teach us, at others coſts, and without our hazard, the true art of what warfare we are all ſo highly concerned in. And, as chymiſts obſerve in the book of nature, that thoſe ſimples, that wear the figure or reſemblance (by them termed ſignature) of a diſtemper'd part, are medicinal for that part of that infirmity, whoſe ſignature they bear; ſo, in God's other book, the vicious perſons there mentioned ſtill prove, under ſome notion, or upon ſome ſcore or other, antidotal againſt the vices notorious in them, being (to preſent it you alſo in a ſcripture ſimile) like the brazen ſerpent in the wilderneſs, ſet up to cure the poiſon infuſed by thoſe they reſemble. *Whatſoever things were written afore-time*, ſays the Apoſtle, *were written for our inſtruction*. And, to make further uſe of our former compariſon, thoſe, to whom the ſcripture gives the names of lions, wolves, foxes, and other brutes, by God's aſſiſtance, prove to his ſaints as inſtructive beaſts, as doth the northern bear unto the wandering pilot. And, as antiently God fed his ſervant *Elias*, ſometimes by an angel, ſometimes by a woman, and ſometimes too by ravens, ſo doth he make all perſons in the bible, whether good, or bad, or indifferent, ſupply his ſervants with that inſtruction, which is the aliment of virtue, and of ſouls, and makes them and their examples contribute to the verification of that paſſage of St. *Paul*, wherein he ſays, that *all things co-operate for good to them that love God*.

Rom. ix. 6.

Rev. ii. 24.

Rom. xv. 4.

Rom. viii. 28.

MY third conſideration is this: That the ſeveral books of the bible were written chiefly and primarily to thoſe, to whom they were firſt addreſſed, and to their contemporaries; and that yet the bible not being written for one age of people only, but for the whole people of God, conſiſting of perſons of all ages, nations, ſexes, complexions and conditions, it was fit it ſhould be written in ſuch a way, as that none of all theſe might be quite excluded from the advantages deſigned them in it. Therefore were theſe ſacred books ſo wiſely, as well as graciouſly, temper'd, that their variety ſo comprehends the ſeveral abilities and diſpoſitions of men, that (as ſome pictures ſeem to have their eyes directly fix'd on every one that looks on them, from what part ſoever of the room he eyes them) there is ſcarce any frame of ſpirit a man can be of, or any condition he can be in, to which ſome paſſage of ſcripture is not as patly applicable, as if it were meant for him, or ſaid to him as *Nathan* once did to *David*, *Thou art the man*. What has been

2 Sam. xii. 7.

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thus obſerved touching God's deſign in the contrivance of the ſcripture, may aſſiſt us to defend the ſtyle of a great multitude of its texts, and particularly of divers of thoſe, which belong to the five following kinds.

AND firſt, the ſeveral books, that make up the canon of the Scripture, being primarily deſigned for their uſe, that lived in the times wherein they were divulged, it need be no wonder, if each of them contain many things, that principally concern the perſons that then lived, and be accordingly written in ſuch a way, that many of its paſſages allude, and otherwiſe relate to particular times, places, perſons, cuſtoms, opinions, ſtories, *&c.* which, by our formerly-mentioned want of a good account of ſuch remote ages and regions, cannot afford us that inſtruction and ſatisfaction, that thoſe, to whom ſuch books were immediately addreſſed, might eaſily derive from the peruſal of them.

NEXT, as ſome portions of ſcripture were principally deſigned for ages very long ſince paſt, ſo ſome other parts of it, eſpecially thoſe that are yet prophetick, may probably reſpect future times, much more than ours: and our poſterity may admire what we cannot now reliſh, becauſe we do not yet underſtand it. Moreover, there being many portions of ſcripture, as almoſt the whole four laſt books of *Moſes*, wherein God is introduced as either immediately, or mediately giving laws to his people, or his worſhippers, I ſuppoſe it will not be thought neceſſary, that ſuch parts of ſcripture ſhould be eloquently written, and that the ſupreme legiſlator of the world, who reckons the greateſt kings amongſt his ſubjects, ſhould, in giving laws, tye himſelf to thoſe of rhetorick; the ſcrupulous obſervation of which would much derogate from thoſe two qualities, ſo conſiderable in laws, clearneſs and majeſty.

BESIDES, there being a ſort of men, of which I hope the number will daily encreaſe, who have ſuch a deſire, as St. *Peter* tells us the angels themſelves cheriſh, to look into the myſteries of religion, and are qualified with elevated and comprehenſive intellects, to apprehend them in ſome meaſure; it is not unfit, that to exerciſe ſuch mens abilities, and to reward their induſtry, there ſhould be ſome abſtruſe texts of ſcripture fitted to the capacities of ſuch ſpeculative wits, and above the reach of vulgar apprehenſions.

1 Pet. i. 12.

AND, on the other ſide, the omniſcient author of the ſcripture foreſeeing, that it would follow from the condition of mankind, that the greateſt part of the members of the church would be no great clerks, and many of them very weak or illiterate, it was but ſuitable to his goodneſs, that a great many other paſſages of the books deſigned for them, as well as others, ſhould be written in ſuch a plain and familiar way, as may befit ſuch readers, and let them ſee, that they were not forgotten, or overlooked by him, who truly ſays, by the prophet, that *all ſouls are his.* And yet in many, even of theſe texts, which ſeem chiefly to have been deſigned to teach the ſimple, ſcholars themſelves may find much to learn. For not only there are ſome paſſages, that contain milk for babes, and others, that exhibit ſtrong meat for riper ſtomachs, but oftentimes (as cows afford both milk and beef) the ſame texts, that babes may ſuck milk from, ſtrong men may find ſtrong meat in: the ſcripture itſelf in ſome ſenſe fulfilling the promiſe made us in it, that *Habenti dabitur* (*to him that hath ſhall be given*) and being like a fire, that ſerves moſt men but to warm, and dry themſelves, and dreſs their meat, but ſerves the ſkilful chymiſt to draw quinteſſences and make extracts.

Ezek. xviii. 4.

I DOUBT not but you are acquainted as well as I with divers querulous readers, who very boldly find fault with this variety, wherein God hath thought fit to exhibit his truth, and declare his will in holy writ, and preſume to cenſure ſome texts as too myſterious, very many as too plain. But theſe exceptions at the oeconomy of the ſcripture do commonly proceed from their pride, that make them; for that vice, inclining them to fancy, that the bible either was or ought to have been written purpoſely for them, prompts them to make exceptions ſuitable to ſuch a preſumption; and, whilſt they look upon their own abilities as the meaſure of all diſcourſes, to call all that tranſcends their apprehenſions, dark, and all that equals it not, trivial. They will be always finding fault with the Holy Ghoſt's expreſſions, both where his condeſcenſions make them clear, and where the ſublimity of the matter leaves them obſcurer; like bats, whoſe tender eyes love neither day nor night, and are only pleaſed with (what is alone proportioned to their weak ſight) a twilight, that is both or neither. But as a ſkilful fowler (and the compariſon will be excuſed by thoſe, that remember that God in ſcripture is ſaid to be preſſed as a *cart is preſſed that is full of ſheaves*, and the ſon of man to be as *a thief in the night,*) according to the differing natures of his game, ſo contrives and appropriates his ſtratagems, that ſome he catches with light, (as larks with day-nets;) ſome with baits, (as pigeons with peas;) ſome with frights, (as black-birds with a ſparrow-hawk or a low-bell;) and ſome he draws in with company, (as ducks and ſuch like ſociable birds with decoy-fowl:) ſo God knowing that ſome perſons muſt be wrought upon by reaſon, others allured by intereſt, ſome driven in by terrour, and others again brought in by imitation, hath by a rare and merciful (if I may ſo call it) ſuppleneſs of wiſdom ſo varied the heavenly doctrine into ratiocinations, myſteries, promiſes, threats and examples, that there is not any ſort of people, that in the ſcripture may not find religion repreſented in that form they are moſt diſpoſed to receive impreſſions from; God therein graciouſly dealing with his children not unlike the prophet, that ſhrunk himſelf into the proportion of the child he meant to revive. The genius's, the capacities and the diſpoſitions of men are ſo diſtinct, and oftentimes ſo extravagant, that there is ſcarce a paſſage of ſcripture, that is not ſuitable or appropriate to ſome of thoſe numberleſs differences of humour the bible was deſigned for; and in that unimaginable variety

Amos xi. 13.

2 King. iv. 34.

of

of occurrences ſhared amongſt ſuch vaſt multitudes, finds not a proper object. And therefore God (who having created them) beſt knows the frame of mens ſpirits, having been pleaſed to match them with proper texts; I ſhall not quarrel with his vouchſafing to liſp myſteries to thoſe, that would be deterred by any other way of expreſſing them, and to qualify his inſtruments according to the natures he deſigns them to work upon, leſt he ſhould ſay to me with the houſe-holder in the goſpel, *Is thine eye evil, becauſe I am good?* And ſure it muſt extremely miſbecome us to repine at the greatneſs of God's condeſcenſions, only upon the ſcore of a knowledge or attainments that we owe to it.

BY reflecting upon the three foregoing general conſiderations, you will, I preſume, eaſily perceive, what it is that is pretended to in what I repreſent to you in the behalf of the ſcripture. For you will eaſily gueſs, by what I have hitherto told you, I pretend not to prove or aſſert, that every text of ſcripture, eſpecially in tranſlations, is embelliſhed with the ornaments of rhetorick, but only to ſhew theſe two things; the one, that as there may be drawn from divers things in the ſcripture it ſelf (without excluding the ſtyle) conſiderable arguments of its having been written or approved by men peculiarly aſſiſted by the ſpirit of God; ſo if a man be perſuaded either by theſe intrinſick arguments, (which I may in another paper evince to be no ſlight ones,) or by any others, of the heavenly origination of the ſcripture; if, I ſay, a man be perſuaded of this, he ought not in reaſon by the ſtyle of theſe books to be kept from diligently ſtudying of them, and highly valuing them. The other (which I add as one evincement of the former) is, that not only the ſcripture is every where written with as much eloquence as the chief author (whoſe omniſcience qualified him to judge beſt in the caſe) thought fit and expedient, as we now have the ſacred books, eſpecially in their originals, very many paſſages of them are ſo far from being deſtitute of what even our weſtern nations count eloquence, that they deſerve to be admired for it. And, *Theophilus*, if you pleaſe to keep in your eye what I have now told you concerning my ſcope in writing, and to bear in your memory the three general conſiderations I have premiſed, I ſhall need hereafter, as often as I have occaſion to mention them, only to point at them; and thereby ſhall excuſe you and my ſelf from the unwelcome trouble of many times repeating the ſame things.

TO proceed then to the more particular objections againſt the ſcripture, the firſt I ſhall conſider is, that it is obſcure. And this I find alledged by two ſort of men to two differing purpoſes; ſome endeavouring by it to diſgrace the bible, and others only making the pretended darkneſs of many of its paſſages an excuſe for their not ſtudying it.

TO the firſt ſort of objectors I anſwer, that it is little leſs than inevitable, that many paſſages of the ſcripture ſhould ſeem obſcure to us, and that it is but fit, that divers others ſhould be ſo too.

FOR firſt, the objectors, as I formerly obſerved, reading the bible but in tranſlations, are deſtitute of thoſe helps to underſtand the ſenſe of many paſſages, that may be afforded by ſkill in the original languages. Beſides, that even to thoſe, that have taken pains to underſtand the original tongues, the genuine ſenſe of divers words and phraſes is denied by the injury of time, through which (as was already noted) a great part of the Hebrew and Chaldean tongues have been loſt.

2dly, MANY texts appear obſcure to thoſe, that live in theſe latter times, only becauſe that by reaſon of the periſhing of thoſe writings and other monuments of antiquity, that were contemporary to the books of the old teſtament, we cannot be ſufficiently acquainted with the hiſtory, the laws and cuſtoms of the *Jews*, and other nations mentioned in the ſcripture; ſo that it need be no wonder if divers paſſages of the books of *Geneſis*, *Joſhuah*, *Judges*, *Samuel*, the *Kings*, *Heſter*, and other hiſtorical books of the ſcripture, as alſo of the four laſt books of *Moſes*, are obſcure to us; and yet might be very intelligible to thoſe, in whoſe times they were written, and for whoſe uſe they were principally deſigned. As although *Lucius Florus* would in many places appear very obſcure to ſuch readers, as know nothing of the Roman affairs, but by the account given of them in his writing, (whence divers late criticks have been invited to illuſtrate him out of other Latin authors) yet queſtionleſs to the Roman readers, that lived in his time, or not very long after, his book was eaſy enough to be underſtood. How much the want of other hiſtorians, contemporary to the penmen of the old teſtament, may make things ſeem obſcure, that might by ſuch ſtories be eaſily cleared up, we may obſerve from divers paſſages of the new teſtament, which can ſcarce be well underſtood without an account of *Herod*'s family, and the changes that happened about our Saviour's time in *Judæa*, which was ſometimes all of it governed by *Herod* the great, that maſſacred the children of *Bethlehem*, and ſometimes was governed by *Pilate* and other Roman magiſtrates; and ſometimes was ſo divided, that it was as to ſome parts only governed by *Herod*'s deſcendants under various titles; the want of the knowledge of which, and of the ſeveral princes that bore the name of *Herod*, does much puzzle many readers, that are ſtrangers to *Joſephus*. And it ſeems ſomewhat ſtrange to many, that Chriſt ſhould in St. *Luke* admoniſh his hearers to fly out of *Jeruſalem* and *Judæa*, and not reſort thither from the neighbouring countries, when they ſhould ſee *Jeruſalem* encompaſſed with armies, ſince thoſe armies would probably hinder the counſelled retirement, (at leaſt as to the city.) Whereas he that finds in the ſtory, that the Roman forces under *Gratus* did on a ſudden, and (as good authors tell us) without any manifeſt cauſe, withdraw from the ſiege of *Jeſuralem*, and then return to it again, and (under *Titus*) carry

Luke xxi. 21, 22.

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carry the town by force; he that ſhall read alſo in *Euſeb. lib. 3. cap. 5.* that the Chriſtians of *Jeruſalem* did (divinely admoniſhed) make uſe of the opportunity preſented them to quit all of them the city, and retire to *Pella* on the other ſide of *Jordan*; he, I ſay, that ſhall read and take notice of all this, will not only clearly underſtand the reaſonableneſs of our Saviour's warning, but admire the prophetical ſpirit by which he could give it. And as it is difficult to collect out of the old teſtament alone the hiſtory of thoſe times, wherein it was written; ſo it is not to be expected, that out of thoſe books we ſhould be able to collect and comprehend, either complete ideas of the Iſraelitiſh government, civil and eccleſiaſtical, or the true ſtate of their ſeveral ſects, opinions and affairs in matters of religion: and yet without the knowledge of thoſe it cannot be, but that many texts will ſeem obſcure to us, which were not at all ſo to them, that were coætaneous to the pen-men of thoſe books. The labours of ſome modern criticks, that have put themſelves to the trouble of making a thorow ſearch into the writings of thoſe Jewiſh Rabbies, that lived about our Saviour's and his Apoſtles times, have, by the help of the rabbinical learning, already cleared up divers texts, which before were dark, becauſe they related to particular ſects, cuſtoms, ſayings, or opinions amongſt the then Jews, whoſe knowledge, the writers of the new teſtament do not teach, but ſuppoſe. And I doubt not, but higher and valuable attainments in that kind of learning (how worthleſs ſoever I ſhould think it, if it were not conducive to the illuſtration of the ſcripture) will, ere it be very long, diſperſe that obſcurity, which yet dwells upon divers other texts, and will ſhew the groundleſſneſs of all our cavils at them, as well as that of many of our too fierce contentions about them. I ſhall add, that I dare almoſt preſume to queſtion, whether even our famouſeſt critics have not left divers Moſaical texts in the dark, if not clouded them by their comments, merely for want of knowing the religion of the antient Zabians, in oppoſition of whoſe magical worſhip and ſuperſtitions, I am apt to think divers ceremonies of the ritual law of the Jews to have been inſtituted. And yet of thoſe Zabiiſts (or צבים and صابئين as the Hebrews and Arabians expreſs the name) I find a deep and general ſilence in claſſic authors, except (the Rabbi's oracle) *Maimonides*, out of whom our great antiquary (Mr. *Selden*) both in familiar diſcourſe, and in his excellent tract of the Syrian deities, gave me firſt a hint, which by lighting on another author of thoſe parts, I have ſince had the luck to improve ſufficiently, to make me fear, that they, who are ſtrangers to the Zabians rites and creed, will ſcarce give us the cleareſt account the theme is capable of in divers paſſages of the Moſaick law. As I am apt to think, that our ignorance or want of taking notice of the perſuaſions and practices of the Gnoſticks, Carpocratians, and the ſects allied to theirs, if it do not make us miſtake and miſinterpret, doth at leaſt keep us from giving the cleareſt interpretations, whereof they are capable, to many paſſages of the New Teſtament, wherein they are either clearly pointed at, or cloſely related to.

3. WE may reaſonably ſuppoſe, that of the texts, that are now difficult unto us, there are divers that are ſo, but becauſe they were principally intended for the uſe of thoſe that ſhall live in after-times, by whom they will queſtionleſs be better underſtood. To the Jews, that lived in and along after *Moſes* his time, many of thoſe predictions, both verbal and typical, of the Meſſias, ſeemed very dark, which to us Chriſtians are abundantly illuſtrated by the riſing of that ſun of righteouſneſs, who was aimed at in them. And though the myſterious temple and city deſcribed in *Ezekiel*, as alſo much of the Apocalypſe, and divers other prophetick paſſages of holy writ, do yet ſeem abſtruſe to us; yet they will not appear ſo to thoſe, to whom their completion (the beſt expoſitor of dark prophecies) ſhall have unfolded them. For I obſerve, that as ſome divine predictions are clearly expreſſed, to the intent that thoſe, that are made acquainted with them, may before-hand know what will happen, ſo others are propoſed, not ſo much that thoſe, to whom they are firſt addreſſed, ſhould know the fore-told events, before they do come to paſs, as that, when they do come to paſs, the ſame accompliſhment, that expounds them, may evince, that the foreteller of them was able to foreſee them, according to that of our Saviour to his diſciples, to whom he propheſied the ſufferings they ſhould undergo; *Theſe things have I told you, that when the time ſhall come, ye may remember that I told you of them.* John xxvi. 4.

4. IT was fit, that there ſhould be ſome obſcure paſſages left in the inſpired volume, to keep thoſe from the knowledge of ſome of thoſe divine myſteries, that are both delightful and uſeful, though not abſolutely neceſſary, who do not think ſuch knowledge worth ſtudying for. As it was alſo fit (which I partly noted above,) that there ſhould be ſome clouded and myſterious texts, to excite and recompence the induſtry and ſpeculation of elevated wits and religious inquirers.

Laſtly, THERE are divers obſcure paſſages in ſcripture, wherein the difficulty lies in the thing it ſelf that is expreſſed, not in the ſcripture's manner of expreſſing it. For not to mention that obſcureneſs, that is wont to attend prophetick raptures, (of which there are many mentioned in the ſcripture) there are divers things, that we agree to be knowable by the bare light of nature without revelation, which yet are ſo uneaſy to be ſatisfactorily underſtood by our imperfect intellects, that let them be delivered in the cleareſt expreſſions men can deviſe, the notions themſelves will yet appear obſcure. Thus in natural philoſophy it ſelf, the nature of place and time, the origin of motion, and the manner whereby the human ſoul performs her functions, are things, which no writers delivered ſo clearly, as not to leave

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leave the things ſomewhat obſcure to inquiſitive and examining readers. And ſhall we then wonder, that thoſe texts of ſcripture, that treat of the nature and decrees of God, and of ſuch ſublime myſteries as the trinity, the incarnation, the influence of the ſpirit upon the ſoul of man, and ſuch other abſtruſe things, which it cannot be reaſonably expected that human words ſhould keep from being hard to be comprehended by human underſtanding, ſhould be obſcure to us; eſpecially if we ſuffer our not underſtanding their full meaning at firſt to deter us from endeavouring to find it out by further ſtudy. I am ſorry I can add on this occaſion, that divers texts are made to appear more dark, than otherways they would, by the gloſſes and interpretations of ſome, that pretend to expound them. For there are divers ſubtle men, who being perſuaded, upon certain metaphyſical notions they are fond of, or by the authority of ſuch either churches or perſons as they highly reverence, that ſuch or ſuch niceties are either requiſite to the explication of this, or that doctrine delivered in ſcripture, or, at leaſt, deducible from it, will make bold ſo to interpret dark texts, (and ſometimes even clear ones) that they ſhall ſeem to hold forth, not only their own ſenſe, but the nice ſpeculations, or deductions of him that quotes them: ſo that divers texts, which, to a rational and unprepoſſeſſed peruſer, would appear plain enough, ſeem to contain inextricable difficulties to thoſe unwary or prejudicate readers, who are not careful to diſtinguiſh betwixt the plain ſenſe of the text itſelf, and thoſe metaphyſical ſubtleties, which witty and intereſted perſons would father upon it; though oftentimes thoſe niceties are either ſo groundleſs, that though there needs much wit to deviſe them, there needs but a little reaſon to deſpiſe them; or ſo unintelligible, as to tempt a conſidering man to ſuſpect, that the propoſers either mean not what they ſpeak, or underſtand not what they ſay. And I could wiſh theſe metaphyſical quirks, with which ſeveral, not only ſchool-men, but other writers, have perplexed the doctrine of predeſtination, of the trinity, of the operation of the ſpirit of God upon the will of man, and ſome other myſteries of Chriſtian religion, did not give advantages againſt thoſe doctrines to the oppoſers of them, and perhaps make ſome men oppoſers, who otherwiſe would not have been ſo. And I fear, that too great an opportunity has been afforded to atheiſtical wits, by unintelligible fancies, which many have made bold to add to what the ſcripture has revealed, concerning the eternity and infiniteneſs of God. For whilſt men indiſcreetly and unſkilfully twiſt together, as integral parts of the ſame doctrine, a revealed truth with their own metaphyſical ſpeculations about it, though theſe be too often ſuch as cannot be proved, or perhaps ſo much as underſtood; they tempt ſuch examining readers, as are rational enough to diſcern the groundleſſneſs of one part of the doctrine, to reject the whole for its ſake. But I fear I have digreſſed, for my intention was only to intimate, that it is not oftentimes ſo much what the ſcripture ſays, as what ſome men perſuade others it ſays, that makes it ſeem obſcure: and that as to ſome other paſſages, that are ſo indeed, ſince it is the abſtruſeneſs of what is taught in them, that makes them almoſt inevitably ſo, it is little leſs ſaucy, upon ſuch a ſcore, to find fault with the ſtyle of the ſcripture, than to do ſo with the author for making us but men.

THUS much being ſaid, by way of anſwer, to the firſt ſort of objectors of darkneſs againſt the ſcripture, it is eaſy to foreſee, that the ſecond ſort of them may endeavour to pervert what has been delivered to apologize for their neglect of the ſcripture, by alledging, that albeit what has been repreſented may ſerve to ſhew, that the obſcurity of the ſcripture is juſtifiable; yet the very proving it needful or fit, that it ſhould be obſcure, is a plain confeſſion that it is ſo. Wherefore it is requiſite, that I now ſay ſomething to this ſort of objectors alſo, who are ſo unfavourable to the ſcripture and themſelves, as that, becauſe they cannot underſtand all of it, they will not endeavour to learn any thing from it. I have already acknowledged it, and ſhall not now deny, that (as heaven it ſelf is not all ſtars) there may be parts of ſcripture, whoſe clear expoſitions ſhall ennoble and bleſs the remoteſt of ſucceeding ages, that perhaps ſome myſteries are ſo obſcure, that they are reſerved to the illumination and blazes of the laſt and univerſal fire.

BUT here it would be conſidered in the firſt place, that thoſe texts, that are ſo difficult to be underſtood, are not neceſſary to be ſo. In points fundamental and indiſpenſably neceſſary, the darkneſs of ſcripture is no leſs partial, than that of *Egypt*, which benighted only the enemies, but involved not the people of God: in ſuch articles as theſe, *If the goſpel be hid, it is hid to them that are loſt, in whom the God of this world hath blinded the minds.* 2 Cor. iii. 4. At leaſt in relation to ſuch truths as theſe, we may juſtly apply that of *Moſes*, where he tells *Iſrael, This commandment, which I command thee this day, is not hidden from thee, neither is it far off. But the word is very near unto thee, in thy mouth, and in thy heart, that thou mayeſt do it.* Deut. xxx. 11, 12, 13, 14. And ſurely the bible's being appropriate (as it ſelf tells us) *to enlighten the eyes, and to make wiſe the ſimple*; Pſal. xix. 7, 8. and it being written for the uſe of the whole people of God, whereof the greater number are no clerks, things are there expreſſed with an evidence proportionable to the degree of aſſent that they exact, and are as far forth intelligible to pious and induſtrious readers, as they are neceſſary to be underſtood by them; and we may not unfitly ſay of the underſtanding of thoſe cloudy paſſages of ſcripture, what I remember a father ſaid of the ſacrament, *That not the wanting it, but the ſlighting it ſhall condemn men.* It is our duty to ſtudy them, but it is not (always) to underſtand them. *Non privatio, ſed contemptus damnat.*

AND as the knowledge of thoſe texts that are obſcure, is not neceſſary, ſo thoſe others, whoſe ſenſe is neceſſary to be underſtood, are eaſy enough to be ſo. And thoſe are as much

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more numerous than the others, as more clear. Yes, there are ſhining paſſages enough in ſcripture, to light us the way to heaven, though ſome unobvious ſtars of that bright ſphere cannot be diſcerned without the help of a teleſcope. Since God, then, has been pleaſed to provide ſufficiently for our inſtruction, what reaſon have we to repine, if he have in a book, not deſigned for us alone, provided alſo for thoſe, that are fitted for higher attainments? eſpecially ſince, if we be not wanting to ourſelves, thoſe paſſages, that are ſo obſcure as to teach us nothing elſe, may at leaſt teach us humility.

NOR does it miſbecome God's goodneſs, any more than his wiſdom, to have ſo tempered the canonical books, as therein to leave all ſorts of readers an exerciſe for their induſtry, and give even the greateſt doctors continual inducements to implore his inſtructions, and depend on him for his irradiations, by leaving, amongſt many paſſages that ſtoop unto our weakneſs, ſome that may make us ſenſible of it. It ſhould, methinks, be looked upon as the prerogative, not the diſparagement, of the ſcriptures, that the revelation of his truth, vouchſafed us by God in them, is like a river, wherein a lamb may quench his thirſt, and which an elephant cannot exhauſt. I ſhould think him but an ill-natur'd child, who ſhould be angry to ſee ſtrong meat provided for his elder brothers, becauſe he himſelf can yet digeſt nothing but milk: and as the ſame child, being grown up to riper years, would be then troubled, that, according to his firſt envious wiſh, there were no ſtronger aliment provided in the family than milk; ſo when, by the attentive and repeated peruſal of the ſcripture, a child in knowledge ſhall attain to ſome higher meaſure of ſkill in the ſcriptures, he will then be well pleaſed to have his underſtanding exerciſed by thoſe moſt myſterious texts, of which he formerly complained that they ſurpaſſed it. However, ſince there are ſo many plain paſſages of ſcripture, that clearly hold forth, not only all that is neceſſary for us to know, but, I fear, much more than we are careful to learn and practiſe, the zealous Chriſtian would no more decline feeding on this heavenly food, though all the hard places ſhould ſtill remain ſuch to him, than the Jews would forbear to eat the paſchal lamb, *though not a bone of it were broken*. And, in earneſt, would not he merit unrelieved beggary, that ſhould refuſe the profit of a rich mine, becauſe all thoſe of the world are not yet diſcovered, nor thoſe of the *Indies* exhauſted?

Exod. xii. 46.

MOREOVER, the pretended obſcureneſs of the bible is a miſtaken diſcouragement from reading it: for the frequency of reading it ſtill leſſens that obſcurity; which, like a miſt, ſeems thicker at a diſtance, than when one enters it, and attempts a paſſage through it; which, in our caſe, many pious ſtudents have done ſo proſperouſly, as to find, by welcome experience, that what, at a diſtance, deterred them, was not intended to fruſtrate induſtry, but puniſh lazineſs.

BESIDES that, the ſcripture being avowedly the beſt expoſitor of itſelf, our ignorance of thoſe places, whoſe ſenſe we ſeek for, makes us often occaſionally much knowinger, and more perfect in the meaning of all the reſt; and makes us too ſo much more ready in the uſes of them, that I cannot but apply to this ſubject the fable of that dying huſbandman, who, by telling his ſons of a hidden maſs of wealth he had buried in a nameleſs place of his vineyard, occaſioned their ſo ſedulous delving all the ground, and turning up the earth about the roots of the vines, that they found indeed a treaſure, though not in gold, in wine: for thus out of hope, by the light of underſtood ſcriptures, to penetrate the ſenſe of the obſcurer ones, we occaſionally ſo improve our knowledge and readineſs in the clearer paſſages, that our by-acquiſts do richly recompence our fruſtrated (or rather unſucceeding) pains; ſince our particular diſappointments hinder not the promotion of our general deſign, which is a greater proficiency in ſpiritual knowledge, and therefore ought not to deter us from the duty of thoſe ſearches, in which not only to diſcover is happy, but even the unſucceeding attempts are gainful, whatever the event be; the pains being ſeldom fruitleſs, but reaching either their end or recompence. And this prompts me to repreſent to you further, that not only the ſcripture is inſtructive upon the ſame account with other theological writings, but that we may hope to improve our underſtandings by it upon this ſcore, that it is alſo the inſtituted means, as well of knowledge, as of grace, and appointed for our inſtruction by him, who, as ſin came into the world by man's liſtening to the words of the devil, is pleaſed to make reſtoring-grace operate chiefly by our liſtening to the word of God, whether heard or read. Wherefore thoſe, whom the intuition of this encouragement invites to be diligent peruſers of the ſcripture, do to their unfirm underſtandings, as the inhabitants of *Gennazareth* did to their ſick and weak countrymen, lay them in *Jeſus* his way, and conſequently in that of recovery. It is of (at leaſt one of) the darkeſt books of the ſcripture, that it is ſaid, *Bleſſed is he that readeth, and they that hear the words of this prophecy*. The eunuch in the *Acts* would (though upon the highway) needs read the Prophet *Iſaiah*, and though (as appears by his queſtion to *Philip*) as then he underſtood not what he read, yet did the Spirit take thence (perhaps a riſe, as well as) opportunity to reveal Chriſt unto him, and both ſatisfy him of the meaning of that prediction, and acquaint him with the freſh and happy accompliſhment of it. And ſurely this conſideration of the bible being one of the conduit-pipes, through which God hath appointed to convey his truths, as well as graces, to his children, ſhould, methinks, both hugely animate to the ſearching of the ſcriptures, and equally refreſh us in it. For as no inſtrument is weak in an omnipotent hand, ſo ought no means to be looked upon as more promiſing, than that which is like to be proſpered by grace, as it is deviſed by omniſcience. We may confidently expect God's bleſſing upon his own inſtitutions, ſince we know, *that whatſo-*

Mark vi. 56.

Rev. i. 3.

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1 John v. 14. *ever we ask according to the will of God, he will give it us*; and we can ſcarce aſk any thing more agreeable to the will of God, than the competent underſtanding of that book, wherein his will is contained.

THE difficulty ought not to deter us from the duty of ſearching the ſcriptures, the difficulteſt commands of God being a warrant to a believer's confidence of being enabled acceptably (though not exactly) to obey them; which St. *Peter* ſeems to have known well in the theory, though he failed in the practice, when to Matth. xi. 28. be enabled to walk upon the ſea, he deſires only, that our Saviour would pleaſe to command him to come to him upon the water. The bible is indeed, amongſt books, what the diamond is amongſt ſtones, the preciouſeſt, and the ſparklingeſt, the moſt apt to ſcatter light, and yet the ſolideſt, and the moſt proper to make impreſſions. But were it as unſuitable to its end, as it is the contrary, I ſhould remember, that John ix. 6. our Saviour could ſucceſſively employ even clay and ſpittle to illuminate blind eyes: and though I thought the bible to be, on other accounts, no more than equal to other books of morality and devotion, God's deſignation would make me ſtudy it more hopefully, by minding me of that of the Syrian leper, when he would needs have *Abana* and *Parphar*, rivers of *Da-* 2 Kings *maſcus*, likely to be as medicinal for his diſeaſe v. 12. as *Jordan*; and vainly fancied, that God's appointment could not put a difference betwixt things that knew no other.

I KNOW, that becauſe of the intermixture of ſome obſcurer texts of ſcripture with the clear ones, there are divers well-meaning, and even devout perſons, that leave the ſtudy of it for that of other books of religion, which, by leaving out all ſuch difficulter matters, ſeem to promiſe more of inſtruction. But, notwithſtanding this, I ſhall not much ſcruple to affirm, that as the moon, for all thoſe darker parts we call her ſpots, gives us a much greater light than the ſtars, that ſeem all luminous; ſo will the ſcripture, for all its obſcurer paſſages, afford the Chriſtian and Divine more light than the brighteſt human authors.

TO diſpatch, ſince the ſcripture is both a naturally proper, and an inſtituted inſtrument, to convey revealed knowledge to the ſtudies of it; and, in it, many clear paſſages may inſtruct ordinary capacities; and its darker ones may either recompenſe more inquiſitive wits, or humble them: I ſee not, why the obſcureneſs of a ſmall part of it ſhould deter any ſort of pious perſons from the peruſal of the whole. Pſal. cix. 105 And, as the word of God is termed a *light*, ſo Prov. vi. 23. hath it this property of what it is called, that both the plaineſt ruſticks may, if they will not wilfully ſhut their eyes, by the benefit of its light, direct their ſteps, and the deepeſt philoſophers, may be exerciſed, if not poſed and dazzled, with its abſtruſer myſteries. For thus, in the ſcripture, the ignorant may learn all requiſite knowledge, and the moſt knowing may learn to diſcern their ignorance.

The ſecond OBJECTION.

TO proceed now to the ſecond objection againſt the ſtyle of ſcripture: the ſeemingly diſjointed method of that book is by many much cavilled at; to which, were the ſuppoſal a truth, I might reply, that the book of grace doth but therein reſemble the book of nature; wherein the ſtars, (however aſtronomers have been pleaſed to form their conſtellations) are not more nicely or methodically placed, than the paſſages of ſcripture, that where there's nothing but choice flowers, in what order ſoever you find them, they will make a good poſy: that it became not the majeſty of God to ſuffer himſelf to be fettered to human laws of method, which, deviſed only for your own narrow and low conceptions, would ſometimes be improper for, and injurious to his, who may well ſay (as he doth in the Prophet) that his thoughts are ſo far from being ours, that, *As the heavens are higher than the earth, ſo are* Iſa. lv. 8, *his thoughts higher than our thoughts*: that, as 9. a mixture of amber-greaſe and muſk is more redolent than the ſingle ingredients; and as, in compound medicines, (as mithridate and treacle) the mixture gives the electuary a higher virtue than the ſever'd drugs poſſeſſed; ſo, oftentimes in morality and divinity, a complication of precept and example, of rhetorick and myſtery, may operate better than their diſtinction would. And ſure we ſhould judge that man a very captious creature, that ſhould take exception at a proffer'd ſum, only becauſe the half-crowns, ſhillings, and ſixpences, were not ſorted in diſtinct heaps, but huddled into one. This, I ſay, with much more, might be repreſented, were the ſcripture-ſeries as deſtitute of method, as pretended. But the truth is, that the method, though it be not pedantically nice, is proper and excellent; (if the goodneſs of a method be to be judged leſs by the order of the ſections, than its being in order to the author's end) and never ſwerved from, but upon ſufficient ground, or for ſome myſterious purpoſe; the laws of order in the ſcripture being rarely declined, but, as the laws of nature are in the world, for man's inſtruction. The hiſtorical diſlocations have their particular reaſons, and, for the moſt part, are accounted for by judicious expoſitors: and as for the frequent (and ſometimes long) digreſſions, excepted againſt in the epiſtles of St. *Paul*, were he a bare human writer, I ſhould poſſibly attribute his frequent excurſions to his fulneſs upon all ſubjects, not his want of ſkill to proſecute any one; and compare his pen to thoſe generous horſes, who, though never ſo well managed, will ever be jetting out on this or that ſide of the path, not out of undiſciplineneſs, but purely out of mettle. But, looking upon St. *Paul* under another notion, I ſhall rather chooſe to tell you, that as rivers are ſaid to run to the ſea, though often-times the interpoſition of hard or riſing grounds, or other obſtacles, force them to ſuch winding meanders, that they ſeem to retreat from the ocean they tend to; which nevertheleſs, with increaſed ſtreams, they afterwards bend again their intermitted courſe to, having watered and fertilized, by their paſſage, the grounds

grounds, through which they ſeemed to wander; ſo our Apoſtle, though he direct his courſe to his main ſcope, may not only without declining it, but in order to it, (for in ſome caſes the wiſdom of the proverb will inform us, that the longeſt way about, is the neareſt way home,) ſeem for a while to abandon it, by fetching a compaſs to anſwer ſome obvious, or anticipate ſome tacit objection; and afterwards more proſperouſly reſume his former conſiderations, now ſtrengthened by the defeat of the interpoſing ſcruples, having by the by happily illuſtrated and enriched thoſe ſubjects, which his incidental excurſions led him occaſionally to handle. I muſt add, that in St. *Paul*'s, as in the reſt of the inſpired writings, the meer want of heeding the Holy Ghoſt's way of writing makes the method appear to us at a very great diſadvantage. For in the hiſtorical parts of ſcripture, when the order of time is interrupted, thoſe προθύστερα προλήψεις and ἐπάνοδοι, and ſuch diſlocations, are uſed oftentimes only to comply with the connexion of the matter; and either diſpatch all that belongs to the ſame long narrative at once, or elſe to join paſſages allied in ſome other circumſtance, though ſever'd in that of time; and ſometimes too things are inſerted, which do not readily ſeem pertinent to the ſeries of the diſcourſe, but are extremely ſo to ſome ſcope of the author, and afford much light and excellent hints to the reader. Sometimes the coherence, where it appears defective, may be very well made out, by rendering Hebrew verbs (and ſome Greek aoriſts) in a preterpluperfect ſenſe inſtead of a perfect; or by ſome ſuch other grammatical variation of the words, as all, that underſtand Hebrew well, know to be allowed by the propriety of that tongue, which ignores divers moods and tenſes, *&c.* of our weſtern languages. Sometimes that, which ſeems incoherent to a diſcourſe, ſerves really to prevent a foreſeen (though perhaps not always obvious) probability of the miſapplication of it; and ſo muſt not be judged impertinent to a doctrine, which it hinders from being either ſcrupled at, or abuſed. Sometimes the prophets in the midſt of the mention of particular mercies promiſed to, or judgments denounced againſt the people of God, ſally out into pathetical excurſions relating to the Meſſias, which ſeem extremely abrupt and incoherent with the reſt to them, that conſider not how ſeaſonable the mention of Chriſt may be, both in that of the mercies of God, of which he is the foundation and pinnacle, the ground and conſummation, (and the promiſe made of him, taught the faithful to reaſon thus with his Apoſtle, Rom. viii. 32. *He that ſpared not his own Son, but delivered him up for us all, how ſhall he not, with him, alſo freely forgive us all things?*) and with the threats of the judgments of God, in which he John. xiii. 13. was his people's grand conſolation. Sometimes 2 Pet. xi. 25. ὁ διδάσκαλος, the teacher, that biſhop of our 1 Tim. iii. 2. ſouls, who was in the ſupreme degree of perfection, which St. *Paul* required of a biſhop, διδακτικὸς, both fit and forward to teach, takes a riſe from any invitation, either of a word, expreſſion, or theme, though belonging to his own firſt ſubject, to give further inſtructions, by digreſſing a little to that occaſional and intervening theme; which, however it related to his matter, ſuited very well with his merciful inclinations to inſtruct dim mortals. Sometimes, nay oftentimes, the inſpired diſcourſers ſeem to ſay things, not only incoherent, but contradictory; (as is very remarkable in divers of St. *Paul*'s epiſtles, where he ſeems to praiſe and diſpraiſe the ſame perſons,) whereas addreſſing themſelves to mixt aſſemblies, wherein (as *Noah* and *Ham* in the ark, and the tares and the wheat *in agro Dominico*) there were both good and bad men, hereticks, eſpecially Gnoſticks, and orthodox Chriſtians; they only ſo wiſely diſpenſed and tempered their diſcourſe, that both theſe ſorts of perſons might find ſomething, in what was in general terms delivered, to appropriate to themſelves in particular; which application was neceſſarily left to their own conſciences to make. Sometimes the order is in ſcripture much diſturbed, or injured, by the omiſſion or miſplacing of a parentheſis. For there not being any in the Hebrew copies, nor (as it is thought) in the original Greek ones, the publiſhers of the ſeveral editions of the bible have placed parentheſes as they have judged moſt convenient; ſome including in them what others leave out of them; and ſome making long ones, where others make none at all; and perhaps none of them having been ſo happy, as to leave no room for alterations, that may deſerve the title of corrections and amendments. And ſometimes too, the ſeeming immethodicalneſs of the new teſtament (not to determine any thing of the antiquity, which is certainly great, and the authority of the accents, and partition of the old teſtament, becauſe amongſt very able criticks *adhuc ſub judice lis eſt*) is due to the inconvenient diſtinction of chapters and verſes now in uſe: which though it be a very great help to the memory, and be ſome other ways ſerviceable; yet being of no greater antiquity than its contriver *Stephanus*, and being (though now of general uſe) but of private authority, and by him drawn up in haſte; it will be perhaps no ſlander to that induſtrious promoter of heavenly learning, to ſay, he hath ſometimes ſever'd matters, that ſhould have been left united, and united others, which more conveniently he might have ſever'd; and that his lucky attempt ought not to lay any reſtraint upon the other learned men, from making uſe of the ſame liberty he took in altering the former partitions, (for of them I ſpeak, not of the punctation) of the new teſtament, in altering his alterations, to the beſt advantage of the ſenſe or method. The analytical works of ſome (I wiſh I could ſay many) judicious expoſitors and divines upon the ſcripture may ſufficiently manifeſt its being generally reducible enough to a perſpicuous order; and that it conforms to the known laws of method, where its diviner one doth not tranſcend them. And it were not impoſſible for me to give divers inſtances to manifeſt, that as the northſtar, though it be leſs luminious than many others,

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others, yet, by reaſon of its poſition, doth better guide the pilot, than even the moon herſelf: ſo there are ſome texts in ſcripture, which, though leſs conſpicuous in themſelves, are, by reaſon of their relation to a context, more inſtructive than other more radiant paſſages; to which theſe would be much inferior, if they were not as well conſiderable for their being there, as ſuch.

The third OBJECTION.

ALLIED to their objection, who find fault with the ſcripture for being immethodical, is theirs, who would fain perſuade us, that it is ſeldom coherent, and ſcarce any where diſcurſive. And I have obſerved, with trouble, that even ſome pious readers are eaſily tempted to look upon the bible as barely a repoſitory of ſentences and clauſes, where divine truths lie huddled, and not ranged, and are too ready to apply to its texts the title *Nero* gave *Seneca*'s ſtyle, of *arena ſine calce.* Whereas an intelligent and attentive peruſer may clearly enough diſcern, both that the prophets and apoſtles do make frequent deductions and inferences, and that their arguments, though not caſt into mood and figure, are oftentimes as cogent as theirs, that uſe to make ſyllogiſms in *Barbara.* I frequently entertain my ſelf with both thoſe authors, and yet methinks, St. *Paul* reaſons as ſolidly, and as acutely, as *Ariſtotle:* and certainly according to *David*'s logick, (*He that planted the ear, ſhall he not hear? He that framed the eye, ſhall he not ſee? He that teacheth man knowledge, ſhall not he know?*) the firſt and grand author of reaſon ſhould as well know how to manage and diſcloſe that faculty, as they that poſſeſs it but by participation, and gliſter ſo but with ſome few condeſcending beams, vouchſafed by that bright ſun, who is indeed the *father of lights, from which each good and perfect gift deſcends.* But on this occaſion, to point at a few particulars, I conſider,

Pſal. xciv. 7, 10.

Jam. i. 17.

1. THAT ſome ratiocinations of ſcriptures remain undiſcerned or miſunderſtood, becauſe of our unacquaintedneſs with the figurative, and (oftentimes) abrupt way of arguing, uſual amongſt the Eaſtern people, who in their arguments uſed to leave much to the diſcretion and collection of thoſe they dealt with; and diſcourſed at a wide diſtance from the logical forms of our European ſchools, as to perſons verſed in their writings cannot but be notorious.

2. THAT the ſeeming incoherency of many ratiocinations proceeds purely from the miſrendering of the original particles, eſpecially of the Hebrew conjunction copulative Vau, or Vaf, (as it is diverſly pronounced by the Jews, of whom I ſhall here advertiſe you once for all, that they have confeſt to me, they differ in pronouncing Hebrew, not only from the Chriſtians, but exceedingly from one another) for there is hardly any of thoſe particles, that hath not, beſides the obvious various ſignifications, of which, if that were ſkilfully and freely in every text taken up, that would there afford the beſt ſenſe, the ſcripture would, I am confident, appear much more coherent and argumentative than tranſlations or expoſitors are wont to make it: and though I did but conſider, how many thouſand times the particle Vaf, is uſed in the ſcripture, and that it doth not only (though it do primarily) ſignify AND, but hath alſo (I ſpeak within compaſs) four or five and twenty other ſignifications (as *that, but, or, ſo, when, therefore, yet, then, becauſe, now, as, though,* &c.) and that the ſenſe only gives it this great diverſity of acceptions; I cannot but think, that if we always allowed our ſelves an equal freedom in rendering it, where the motive (which is the exigency or conveniency of the ſenſe) is the ſame; the dextrous uſe and rendering of that one particle would make no ſmall number of texts both better underſtood, and more eſteemed.

3. THAT ſometimes (eſpecially in *Solomon*'s and St. *Paul*'s writings) in many paſſages ſo penned as to contain (like *Seneca*'s) a tacit kind of dialogue, that is unſkilfully by readers, and even interpreters, taken for an argument or an aſſertion, which is indeed an objection: and that ſuch a miſtake muſt mightily diſcompoſe the contexture of a diſcourſe, even a raw logician need not to be told.

4. THAT the omiſſion or miſplacing of parentheſes (which the Hebrew text altogether wanting, interpreters have ſupplied and uſed at their own diſcretion) makes the ſcripture oftentimes appear leſs diſcurſive, as well as (what we elſewhere complain of) leſs methodical. And the like may be ſaid of the points of interrogation. For whether it be true or no what the criticks eſteem, that in the original Greek copies of the new teſtament there were no ſuch points, (as indeed I have found them wanting in the ancienteſt manuſcripts I have ſeen) it is certain, that in our modern copies, both Greek and tranſlated, the authors of ſeveral editions have variouſly placed them, as themſelves thought fit: and though, inſtead of the interrogative point, the Hebrews make uſe of their interrogative *He*; yet that the ſenſe of the words, and a certain ſuppoſed modulation, do oftentimes make an interrogation, where that *He* is wanting, an Hebrician can ſcarcely ignore, no more than a logician, that the interrogation is not always ſupplied to the beſt advantage of the ſcripture's logick.

5. THAT the apoſtles and other inſpired diſcourſers in the bible divers times uſe arguments, not to convince oppoſers, but to confirm believers. For the perſons they reaſon with, being ſuch, oftentimes, as eſteem them teachers ſent from God, upon whoſe ſcore all they teach exacts belief, they may without irrationality uſe arguments to confirm in their doctrine men already acquieſcing in the principles of it, and perſuaded of their integrity, ſufficiency, and authority, that it would be improper to urge againſt a refractory diſbeliever, that is convinced of none of theſe. And as maſters often uſe, in inſtructing their ſcholars, arguments, they would forbear to inſiſt on

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againſt a profeſſed antagoniſt; ſo the apoſtles dealing with thoſe, that thought them inſpired teachers, and fully inſtructed in the myſteries of ſcripture, and the deſigned diſpenſations of God, might juſtly draw inferences, not to be urged againſt an infidel, from a doctrine firſt delivered by themſelves, or from a text or paſſage, wherein thoſe, they reaſoned with, juſtly ſuppoſed they might know more of the mind and counſel of God than other men; and would teach nothing as ſuch, that was not ſo.

6. THAT arguments exquiſite, and (as artiſts term them) apodictical, had been oftentimes leſs proper in diſcourſes, which being addreſt to popular auditories, required rather popular arguments; which the inſpired diſcourſers employ, but as likely to be better underſtood, and more prevalent than thoſe, which are ſo logical, that they require logicians to reliſh them. Where teaching and perſuading is the deſign, not only the native cogency of a ratiocination is to be conſidered, but its proportion to their ſpirits it is addreſſed to, and its aptitude to work upon them. For as a ſpider will catch flies better than a hawk can; as a cat is more fit to deſtroy mice than a grey-hound, though this be ſtronger and ſwifter; and as the crowing of a cock will (according to famous naturaliſts) ſooner fright a lion than the bellowing of a bull, though the latter be much the more terrifying noiſe, and proceed from the more formidable animal: ſo oftentimes weaker and popular arguments ſucceed better with a reſembling auditory, than the irrefragable ſyllogiſms.

7. THAT divers ſcripture-arguments do not logically and cogently prove the thing they would perſuade, merely becauſe they were meant only for what logicians call *argumenta ad hominem*; (reaſonings deſigned not ſo properly to demonſtrate the opinion they contend for, irrelatively and abſtractedly conſidered, as to convince, of the truth of that opinion, the perſons they are addreſſed to) and conſequently the inſpired diſcourſers arguing *è conceſſis*, from principles conceded and confeſſed by thoſe they reaſon with, though the principles ſhould be unſolid, the ratiocination is not. Thus there are divers texts of the old teſtament applied to Chriſt in the new, which though they did not now inevitably conclude againſt the preſent Jews, were without any illogicalneſs employed againſt their anceſtors; becauſe then the relation of thoſe paſſages to the Meſſias was ſo acknowledged, that there needed but the pertinent applications made of them in the new teſtament; whereas the refractorineſs of the ſucceeding Jews hath taught them to deviſe ſo many ſophiſtical evaſions to elude the texts we ſpeak of, that they now diſpute, not only the application of them, but the explication too. St. *Jude* argues with the rodomonts of his time, out of the ſtory of the arch-angels and the devil's conteſt about the body of *Moſes*: and though perhaps that ſtory be (like the Jewiſh book, whence it ſeems not improbable it was taken) ſomewhat apocryphal; yet as long as they reverenced it, it was not irrational in him to urge them with it, and employ it to the redargution of their inſolence. And, although as there be nothing leſs ſolid and more fickle than the wind, yet the ſkilful pilot diligently obſerves it, and makes it drive on his ſhip more forcibly, than the powerfulleſt and beſt contrived engines in the world could: ſo though there be ſcarce any thing more groundleſs and unſtable than popular opinions and perſuaſions, yet a wiſe teacher neglects them not, and may ſometimes make ſuch uſe of them, as to draw thence arguments more operative than the accurateſt ſyllogiſms logick could deviſe. And indeed the moſt convincing proofs of aſſertions being ever afforded by the mediums, wherein both parties agree, not only *Socrates* in *Plato*'s dialogues, but dextrous diſcourſers generally, have often elected the drawing of inferences from the opinions and conceſſions of thoſe they dealt with, as the moſt perſuaſive and ſucceſsful way of arguing; to all which I ſhall add,

8. THAT another thing, which very generally keeps men from diſcerning the reaſonings (and conſequently oftentimes the reaſonableneſs and true ſenſe) of ſcripture texts, is, the ſlineſs of divines to let the context and the ſpeaker's ſcope regulate their choice, amongſt all the various, though not equally obvious, ſignifications of ambiguous words and phraſes. It is not, that (as far as I have obſerved) men almoſt of all religions are not wont to make bold with (and perhaps for a need to ſtrain or wreſt) phraſes and words of ſcripture, when the giving them leſs uſual notions may fit them to ſerve their turns: but the miſchief is, that they decline the commoneſt acceptions, but to make the texts they quit them in, ſymphonize with their tenents, not with their neighbouring texts. It were methinks impartialler, if the frequenter ſenſe of an expreſſion were to be waved (as oftentimes it muſt) for one leſs current, to do this to make the ſcripture coherent, or diſcurſive: and then, for our opinions, rather to conform them to the ſenſe of the ſcripture, than wreſt the words of ſcripture to them. But perhaps this impartiality would ſilence too many of our clamorous controverſies (by ſhewing ſome to be groundleſs, and others undeterminable) to be likely to take place in the heated ſpirits of men; ſome of whom, I fear, whilſt their feuds and fierceneſs laſt, would be willinger to have the texts of ſcripture looſe ſtones, which they may more eaſily throw at their adverſaries, than built up into a ſtructure, wherein they muſt loſe that convenience, (it being difficult to pluck ſtones out of a building) though reaſon herſelf were the architect.

BUT to leave theſe eager diſputants to their animoſities, we ſhall again repeat, that the bible loſes much by not being conſidered as a ſyſtem. For though many other books are comparable to cloth, in which by a ſmall pattern we may ſafely judge of the whole piece; yet the bible is like a fair ſuit of arras, of which, though a thread may aſſure you of the fineneſs of the colours, and richneſs of the ſtuff, yet the hangings never appear to their

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true advantage; but when they are diſplayed to their full dimenſions, and ſeen together.

THESE things, *Theophilus*, among many others, may be repreſented on the behalf of the ſcripture, againſt thoſe, who will needs cenſure it as a collection, not to ſay a heap of immethodical and incoherent paſſages. But leſt you ſhould ſuſpect me of partiality, I ſhould ingenuouſly confeſs to you, that there are ſome things in the oeconomy of ſcripture, that do ſomewhat diſtreſs my reaſon to find a ſatisfactory account of; and that there are very few things, wherein my curioſity is more concerned, and would more welcome a reſolution in. But when I remember, how many things I once thought incoherent, in which I now think I diſcern a cloſe (though myſtick) connection; when I reflect on the author and the ends of the ſcripture; and when I allow my ſelf to imagine how exquiſite a ſymmetry (though as yet undiſcerned by me) omniſcience doth, and after-ages (probably) will diſcover in the ſcripture's method, in ſpite of thoſe ſeeming diſcompoſures that now puzzle me: when I think upon all this, I ſay, I think it juſt to check my forward thoughts, that would either preſume to know all the recluſe ends of omniſcience, or peremptorily judge of the fitneſs of means to ends unknown; and am reduced to think that oeconomy the wiſeſt, that is choſen by a wiſdom ſo boundleſs, that it can at once ſurvey all expedients, and ſo unbiaſſed, that it hath no intereſt to chuſe any, but for its being fitteſt. I ſhall annex, that I think thoſe muſt derogate hugely from the ſcripture, who only conſider the ſenſe of the particular ſections, or even books of it: for I conceive, that (as in a lovely face, though the eye, the noſe, the lips, and the other parts ſingly looked on may beget delight and deſerve praiſe, yet the whole face muſt neceſſarily loſe much by not being ſeen altogether; ſo) though the ſever'd leaves and portions of ſcripture do irrelatively, and in themſelves, ſufficiently betray and evidence their own heavenly extraction; yet he, that ſhall attentively ſurvey that whole body of canonical writings we now call the bible, and ſhall judiciouſly in their ſyſtem compare and confer them to each other, may diſcern, upon the whole matter, ſo admirable a contexture and diſpoſition, as may manifeſt that book to be the work of the ſame wiſdom, that ſo accurately compoſed the book of nature, and ſo divinely contrived this vaſt fabrick of the world. The books of ſcripture illuſtrate and expound each other; *Geneſis* and the *Apocalypſe* are in ſome things reciprocal commentaries; (as in trigonometry the diſtanteſt ſide and angle uſe beſt to help us to the knowledge one of the other:) and as in the mariners compaſs, the needle's extremity, though it ſeem to point purpoſely but at the north, doth yet at the ſame time diſcover both eaſt and weſt, as diſtant as they are from it, and from each other; ſo do ſome texts of ſcripture guide us to the intelligence of others, from which they are widely diſtant in the bible, and ſeem ſo in the ſenſe. It is as high as pious a ſatisfaction to obſerve, how the ſacred pen-men ſupply each other's omiſſions, (as is very obſervable in the four Evangeliſts mention of the genealogy of Chriſt,) according to God's degrees and ſeaſons in diſpenſing the knowledge of his truths and myſteries in the ſeveral ages of the church; (to which he at firſt vouchſafed *but a light ſhining in a dark place until the day dawn*, and to which theſe mutual irradiations and ſecret references perſuade, that all theſe reputed authors had their pens guided by an omniſcient hand, and were but the ſeveral ſecretaries of the ſame enditer) and to find in writers ſevered by ſo many ages, and regions, a harmony, whoſe diſſonances ſerve but to manifeſt the ſincerity and unconſpiringneſs of the writers. And truly for my part, I am profeſſedly enough an impartialliſt, not to ſtick to confeſs to you, *Theophilus*, that I read the bible and the learneded expoſitors on it, with ſomewhat particular aims and diſpoſitions. For beſides, that I come not to them with a croud of articles, which I am there reſolved to find or make arguments to defend, with the overthrow of all antagoniſts, eſteeming it leſs ſafe to carry my opinions to the ſcriptures than to take them up there: beſides this, I ſay, though I neglect not thoſe clear paſſages or arguments, that may eſtabliſh the doctrine of that church I moſt adhere to; yet am I much leſs buſied, and concerned to collect thoſe ſubtile gloſſes or inferences, that can but enable me to ſerve one ſubdiviſion of Chriſtians againſt another, than heedfully to make ſuch obſervations, as may ſolidly juſtify to my own thoughts, and improve in them, a reverence for the ſcripture it ſelf, and Chriſtianity in general; ſuch obſervations as may diſcloſe to me in the bible, and the grand articles clearly delivered in it, a majeſty and an excellency becoming God *himſelf*, and tranſcending any other author; and ſuch obſervations (to diſpatch) as may unveil to me in the ſcripture, and what it treats of, that πολυποίκιλος σοφία τῦ Θεῦ, *manifold wiſdom of God*, which even the angels learn by the church. Theſe are, I confeſs, the things (as to ſpeculative divinity) that I gladlieſt meet with, and take the heedfulleſt notice of, in the writings of divines, of whatſoever religion, that owns the ſcripture; (for in this I am almoſt equally gratified by the abler expoſitors of all diſſenting ſects:) for I can ſcarce think any pains miſpent, that brings me in ſolid evidences of that great truth, that the ſcripture is the word of God, which is indeed the grand fundamental; all other articles generally thought ſo being, if truths, better deducible from this one, than this from any of them. And I uſe the ſcripture, not as an arſenal, to be reſorted to only for arms and weapons to defend this party, or defeat its enemies, but as a matchleſs temple, where I delight to be, to contemplate the beauty, the ſymmetry, and the magnificence of the ſtructure, and to increaſe my awe, and excite my devotion to the Deity there preached and adored.

2 Pet. i. 19.

Eph. iii. 10.

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The fourth OBJECTION,

Of texts seemingly impertinent or useless.

THE apoſtle of the Gentiles teaching us, that the whole ſcripture (for ſo I ſhould rather engliſh the Πᾶσα γραφὴ, becauſe there follows) is θεόπνευστος *divinely inſpired, and is profitable for doctrine, for conviction, for correction, for inſtruction in righteouſneſs; that the man of God may be perfect, thoroughly furniſhed unto all good works:* and the Apoſtle of the circumciſion aſſuring us, that, *Prophecy came not in old time, by the will of man, but holy men of God ſpake as they were moved by the Holy Ghoſt*; we are not to believe, that ſo divine an inditer, by ſecretaries, moſt of them conſpicuous by the gifts of prophecy or miracles, would ſolemnly publiſh to the world, and for his church, any thing, that ought indeed to be accounted impertinent or uſeleſs. And yet of theſe qualities, ſome perſons, more bold than learned and conſiderate, are pleaſed to impeach many paſſages of ſcripture. But truly that God, who was ſo preciſely exact, in the dimenſions, proportions, and all other circumſtances of the ancient tabernacle, though it were but a typical and temporary ſtructure, ought to be ſuppoſed at leaſt as careful to let nothing ſuperfluous intrude into thoſe volumes: which being conſigned to the church, for the perpetual uſe and inſtruction of it, muſt contain nothing unconducive to thoſe deſigns; the leaſt text in it being as contributory to the compleating of the bible, as every loop or pin was to the perfection of the tabernacle. God, by ſo great a condeſcenſion to the weakneſs of our capacities and memories, as the with-holding from the canon ſo many writings of *Solomon*, and ſo many of the oracles and miracles of our Saviour; and by ſo ſtrangely preſerving the whole ſcripture, (for the books pretended to be loſt, though written by never ſo holy men, are either in our bibles extant under other names, or cannot be demonſtrated to have ever been canonical, that is, entruſted with the church as the infallible rule of faith and life) does, methinks, abundantly evince his deſign of inchaſing nothing there, that hath no tendency to his people's inſtruction. Were not my diſcourſe confined by my occaſions, and the fear of diſtreſſing your patience to ſomewhat narrow limits, I could eaſily by ſeveral inſtances of texts, ſeemingly uſeleſs, ſhew, how much men have been miſtaken in imagining them ſuch. Many paſſages, that at the firſt or ſecond reading I could find nor gueſs no uſes of, at the third or fourth I have diſcovered ſo pregnant in them, that I almoſt equally admired the richneſs of thoſe texts, and my not diſcerning it ſooner. A ſuperficial and curſory peruſal preſents us many things as trivial or ſuperfluous, which a perſpicacious reflection diſcloſes to be myſterious. And of ſo precious a quality is the knowledge of ſcripture, that no one part of it ought to be eſteemed uſeleſs, if it may but felicitate or improve the underſtanding of any other; divine truths being of that worth, that the knowledge and acquiſt of a few of them as much out-values a greater knowledge of other things, as a jeweller's ſkill and ſtock is preferred before a maſon's. And I conſider here, that as the bible was not written for any other particular time or people, but for the whole church militant diffuſed through all nations and ages; as many paſſages (as thoſe oppoſed to the *Zabians* magical rites) have at firſt been neceſſary for the Jews, which loſe the degree (at leaſt) of that quality for us. For there are many others very uſeful, which will not perhaps be found ſo theſe many ages; being poſſibly reſerved, by the prophetick ſpirit that indited them, (and whoſe omniſcience comprizes and unites in one proſpect all times, and all events) to quell ſome future foreſeen hereſy, which will not perhaps be born till we be dead; or reſolve ſome yet unformed doubt, or confound ſome error, that hath not yet a name: ſo that all the parts of the ſcripture are uſeful in ſome ages, and ſome in all. We read in the goſpel, that at the firſt inſtitution of the euchariſt, it was expreſly ſaid to the diſciples concerning the ſacramental wine, *Drink ye all of it*, whereas upon the exhibition of the bread the particle *all* is omitted. This difference, it is like, the primitive Chriſtians marvelled at, and diſcerning no reaſon for it, might be tempted to think the paſſage uſeleſs or ſuperfluous: but we that live in an age, wherein the cup is denied to much the greater part of the communicants, are invited not only to abſolve the recording of this particularity, but to admire it. The ceremonial law, with all its myſtick rites (which, like the manger of the ſhepherds, holds forth wrapped in his ſwathing-cloaths the infant Jeſus,) to many, that beſtow the reading on it, ſeems ſcarce worth it: yet what uſe the Apoſtles made of it with the Jews; and how neceſſary the knowledge of it is yet to us, in our controverſies with them, he, that is any thing verſed in them, cannot ignore. And let me tell you, *Theophilus*, that thoſe fundamental controverſies are both more neceſſary and more worthy a wiſe man's ſtudy, than moſt of thoſe comparatively trifling ones, that at preſent ſo miſerably (not to ſay ſo cauſeleſly) diſtract Chriſtendom. How many paſſages of the prophets by lazy readers are thought to have no uſe, which, as the ſtar did the wiſe men, lead the attentive conſiderers to Chriſt; and ſo loudly and harmoniouſly, together with *Moſes*'s typick ſhades, utter thoſe words of the Baptiſt's, *Behold the lamb of God that taketh away the ſins of the world!* that I meet with numerous paſſages in the new teſtament, to which I cannot but apply what St. *Matthew* notes upon his narrative of our Saviour's apprehenſion: *All this was done, that the ſcriptures of the prophets might be fulfilled*; or rather now all this was ſo done, that they were fulfilled; for ſo oftentimes the context commands us to render the ἵνα in theſe citations, and which recall to my mind the hiſtory of the tranſfiguration; for as there the Apoſtles at firſt *ſaw* Moſes *and* Elias *talking with* Jeſus, but at the ſecond view (when the cloud was with-drawn, and he had ſpoken to them) *ſaw none but* Jeſus *only*; ſo ſuch paſſages, as I am ſpeaking of,

2 Tim. iii. 15, 16.

1 Pet xxii. 21.

Mat. xxvi. 27. Mark xiv. 23.

Luke ii.

Mat. i.

John i. 22.

Mat. xxvi. 56.

Mat. xvii. 3, 8.

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of, in the law, the prophets, and the goſpel, at firſt ſurvey appear very diſtinct things, but upon a ſecond inſpection, and the acceſs of more light from an attentive collation of things, they do all, as it were, vaniſh into Joh. i. 55. Chriſt; *of whom* (to uſe an Apoſtle's terms) Moſes *in the law and the prophets did write:* and at whom thoſe types, and thoſe predictions pointed. Thoſe inſtances of the old teſtament, of the confuſed or diſlocated mention of known pedigrees and ſtories, were poſſibly uſeleſs, and even troubleſome to the ancient Jews; but ſerve us extremely to ſilence the cavils of the modern ones, when they would invalidate the new teſtament's authority; becauſe in St. *Stephen*'s narrative, and ſome of the Evangeliſt's genealogies, the Holy Ghoſt is pleaſed to employ, in the new teſtament, that obſcure ſtrain he had oftner uſed in the old: (and ſure as inſultingly as the Jews uſe to urge againſt us objections of that nature, I could readily retaliate, and repay them in the ſame coin, were there no common enemy, that might be advantaged by our quarrel, and employ either's arguments againſt both.) And as there are divers prophetical paſſages in the *Revelation*, which we know as little the uſe, as meaning of, which yet doubtleſly our poſterity will not find barren, when once the accompliſhment ſhall have proved the expoſitor of thoſe predictions, whoſe event will (if it do nothing elſe) atteſt the omniſcience of their inſpirer: ſo poſſibly, of many Moſaick conſtitutions, whereof we Chriſtians find excellent uſes, moſt of the old Jews ſcarce knew any; at leaſt my converſation with our modern Rabbies ſhows me, that they, whilſt they obſtinately decline referring them to the Meſſias, can ſcarce make any more of the inſpired and myſterious laws of *Moſes*, (except thoſe that relate to the Zabian ſuperſtition, with which too moſt of their doctors are as unacquainted as ours) than the Egyptians, or Gymnoſoplifts, could of their ſacrifices and other ritual devotions.

IT is not, that I think all the books, that conſtitute the bible, of equal neceſſity or equal uſefulneſs, becauſe they are of equal extraction; or that I eſteem the church would loſe as much in the prophecy of *Nahum*, as that of *Iſaiah*; or in the book of *Ruth*, as in the epiſtle to the *Romans*, or the goſpel of *John*, (as the fixed ſtars themſelves, though of the ſame heaven, are not all of the ſame magnitude and luſtre.) But I eſteem all the conſtituent books of ſcripture neceſſary to the canon of it; as two eyes, two ears, and the reſt of the members are all neceſſary to the body; without divers of which it may be, but not be ſo perfect; and which are all of great, though not of equal uſefulneſs. And perhaps it might without too hyperbole be ſaid further, that as amongſt the ſtars, that ſhine in the firmament, though there be a diſparity of greatneſs compared one to another, yet they are all of them lucid and celeſtial bodies, and the leaſt of them far vaſter than any thing on earth; ſo of the two teſtaments, that compoſe the bible, though there may be ſome diſparity in relation to themſelves, yet are they both heavenly and inſtructive volumes, and ineſtimably out-valuing any the earth affords, or human pens ever traced. And I muſt add, that as mineraliſts obſerve, that rich mines are wont to lie hid in thoſe grounds, whoſe ſurface bears no fruit-trees, (too much maligned by the arſenical and reſembling fumes) nor is well ſtored with uſeful plants or verdure; (as if God would endear thoſe ill-favoured lands by giving them great portions:) ſo divers paſſages of holy writ, which appear barren and unpromiſing to our firſt ſurvey, and hold not obviouſly forth inſtructions or promiſes, being by a ſedulous artiſt ſearched into, (and the original word ἐρευνᾶν uſed in that text of *Search the Scriptures* does properly enough John v. ſignify the ſearching for hid treaſure) afford, 39. out of their penetrated bowels, rich and precious myſteries of divinity.

The Fifth OBJECTION.

THE next thing imputed to the ſcripture is, that it contains many things trivial or impertinent; and it is not impoſſible, but that ſome things may ſeem ſo, though they are not: of this ſort are diſjointed ſpeeches, and abrupt tranſitions obſerved in many of our Saviour's diſcourſes; in which alſo we ſometimes read him to have anſwered, without being aſked the queſtion, (though that be otherwiſe ſalvable by a critick,) and ſometimes to have anſwered to a quite other queſtion than that he was aſked. But this is not to be thought an abſurdity, but an excellency in the replies of Chriſt; who poſſeſſing the prerogative of diſcerning hearts, did preach after that rate; his oratory took a ſhorter way than ours can follow it in: he proſecuted his deſign by altering his diſcourſes; and wiſely meaſured the fitneſs of his heavenly ſermons, by their relation to his end, not his theme. For as he knew his hearers thoughts, he addreſt himſelf to them; and reaching them in their earlieſt formation, and, as it were, their firſt cradle, before they had leiſure to paſs into the tongue, he not more convinced his auditory by anſwering their thoughts, than by thus manifeſting that he knew them. Of his ſo much undervalued parables, ſome, if not moſt, do (like thoſe oyſters that beſides the meat they afford us, contain pearls) not only include excellent moralities, but comprize important prophecies. The parable of the pregnant grain of muſtard-ſeed, that ſo ſuddenly grew to ſo Mat. xiii. large a plant, was a (now fulfilled) predic- 31, 32. tion of the admirably ſwift progreſs of the goſpel; which from deſpicable beginnings, ſoon proſpered to a height, that rendered it almoſt Mat. xxi. as fit an object for wonder as for faith. That 33. other parable of the treacherous huſband-men clearly foretold Chriſt's death by the Jews malice, and their deſtruction for it. And I deſpair not to ſee unheeded prophecies diſcloſed in others of them, eſpecially being informed that there is a critick, (Monſieur *A. B.*) now at work upon a deſign of manifeſting many otherwiſe interpreted paſſages of the new teſtament to be prophecies; of whom no leſs than the famouſeſt of the modern Rabbies, *Me-*

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naſſe Ben-Iſrael, (one time I made him a viſit at his own houſe in *Amſterdam*) gave me this character, that he took him for the ableſt perſon of the Chriſtians. Thoſe hiſtorical circumſtances quarrelled with, in Chriſt's parables, are like the feathers, that wing our arrows, which though they pierce not like the head, but ſeem ſlight things, and of a differing matter from the reſt, are yet requiſite to make the ſhaft to pierce; and do both convey it to, and penetrate the mark. But nothing is thought more impertinent in the ſcripture than the frequent repetitions. But the learned need not to be told, that many things ſeem to the ignorant, bare repetitions, which yet ever bring along with them ſome light, or ſome acceſſion; in that comparable to the ſtars, which, as like as they ſeem to vulgar gazers, are by the ſkilful aſtrologer taught to contain, under that colour and figure common to them all, very peculiar and diſtinct influences. I here alſo conſider, that in all languages there are ſome cuſtomary geminations and expreſſions, which, though to ſtrangers they appear ſuperfluous, if not abſurd, to the natives, and in the propriety of that ſpeech, are not only current, but oftentimes emphatical. I find withal, that there is ſcarce any of theſe ſeeming impertinencies, of which a learned and judicious expoſitor cannot aſſign a pertinent cauſe or reaſon; and I conſider too, that the books of ſcripture being indited, not all at once, but at very ſeveral and diſtant times, (according to the known ſaying, that *Nunquam ſatis docetur, quod nunquam ſatis diſcitur*) the repetition of the ſame ſins and errors required that of the ſame menaces and diſſuaſions; whoſe frequent enforcing, ſerving both to atteſt and convince the ſinner's obſtinacy, was not a bare repeating, but ſuch a redoubling as we are fain to uſe, to drive in
Ec. xii. 1. a nail to the head; (and the words of the wiſe are, in the wiſe man's words, *As nails faſtned by the maſters of aſſemblies*) where though in all the renewed ſtrokes the buſy hammer gives, the act be ſtill the ſame, yet is no blow ſuperfluous; the number of them ſerving to compleat their operation. They that in peruſing books have the learning and ſkill to ſtrip them, of what oratory or ſtealth hath dreſſed and diſguiſed them in, will eaſily diſcern moſt of them to be but varied repetitions: which for my part I find differing from thoſe of ſcripture, but in that the latter do in the ſame words generally comprize new matters, whereas the former uſually preſent us ſtale matter in new words. And I conſider further, that our own ſad experience ſhowing us, that there is no ſingle text of ſcripture, that ſubtiler hereticks ſophiſtry cannot plauſibly enough elude; the Holy Ghoſt foreſeeing this from the beginning, hath mercifully and wiſely provided, that the fundamental truths of faith and manners ſhould be held forth in ſo many places, and in ſo much variety of expreſſions, that one or other of them muſt unavoidably intercept thoſe evaſions, and eſcape thoſe miſconſtructions, that ſophiſtry may put upon the reſt. Which providence alone hath preſerved many articles from the attempts of hereticks; making them both bluſh to queſtion, and deſpair to diſprove a truth atteſted by more than two or three witneſſes; and giving orthodox believers the ſatisfaction of having their anchor tied to a *threefold cord, which is not eaſily broken*. Moſt of the bible's repetitions (or inculcation rather) teach us ſomething or other untaught before; and, as in *Pharaoh*'s viſion, though both the ears and the kine ſignified the ſame thing, yet *Joſeph*'s interpreta- Gen. xli. 25, 31.
tion ſhows, that neither was ſuperfluous; even thoſe few, that teach us nothing elſe, teach us at leaſt the importance (or ſome other attribute,) of thoſe repeated points we were taught before. And I ſcruple not to compare the expreſſions of the ſcripture to a roſe, where though ſo many leaves nearly reſemble each other, there's not one of them, but contributes to the beauty and perfection of the flower.

The ſixth OBJECTION.

I AM not unacquainted with the קרי *Keri*, and the כתיב *Cethib*; nor the תקון סופרים *Tikkûm Soph'rîm* in the old teſtament: nor yet with the *Variæ Lectiones* (eſpecially thoſe of the Eaſtern and Weſtern Jews, as they are called) taken notice of by modern criticks in the Hebrew text of the old, as well as in the Greek of the new teſtament. I am not neither altogether a ſtranger to the difficulties to be met with, in making good the citations we find made of divers texts of the former of thoſe ſacred inſtruments in the latter: in which they ſeem not unfrequently to differ much from what we find extant in the ancient teſtament, as to the words, and ſometimes too as to the ſenſe. Theſe things, I ſay, though by ſome much urged againſt the ſcripture, I am not ignorant of. But I think it not fit to conſider them in this place; not only, becauſe thoſe, that are much better qualified for ſuch a work than I, have done it already; but becauſe theſe objections relating rather to the truth or the authority, than to the ſtyle of the ſcripture, the nature of my preſent taſk does not oblige me to examine them. Eſpecially, ſince I have already ſaid ſomething of them, and may ſay more, in what I write on the behalf of the Chriſtian religion. And it is upon theſe grounds, *Theophilus*, that I alſo decline at preſent the conſideration of what is wont to be objected, as if it there were a great many ſelf-contradictions to be met with in the ſcripture. Only I ſhall in the mean time invite you to take notice with me, that it is not oftentimes ſo much the various aſpects of the texts, as the divers prepoſſeſſions and intereſts of the expoſitors, that make books ſeem repleniſhed with interfering paſſages and contradictions. For if once the theme treated of do highly concern men's intereſts, let the book be as clear as it can, ſubtile and engaged perſons on both ſides, peruſing it with foreſtalled judgments of biaſſed paſſions, will be ſure to wreſt many paſſages to countenance their prejudices, and ſerve their ends, though they make the texts never ſo fiercely fall out with one another, to reconcile them to their partial gloſſes. Of this I might produce an eminent inſtance in *Ariſtotle*'s

Of contradictions preſumed betwixt paſſages of ſcripture.

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ſtotle's phyſical writings, alledged by ſo many diſſenting ſects of ſchool-men to countenance their jarring opinions; the injured *Stagyrite* (employed as ſecond by every one that quotes him) being by every ſect brought to fight with its antagoniſts, and by them all to give battle to himſelf. Thus do the diſſenting ſects of Mahometans quarrel as well about the ſenſe of their Alcoran, as we do about that of our Bible; and make the one as much a noſe of wax, as the Romiſh catholicks ſay we make the other. Which brings unto my mind, that not only the δυσνόητα τινα, the *ſome things hard* 2 Pet. iii. 16. *to be underſtood* in St. *Paul*'s epiſtles, but alſo the λοίπαι γραφαι, the *other ſcriptures* are by St. *Peter* ſaid to be by the *unlearned and unſtable wreſted to their own deſtruction.* When a ſober author finds an impartial reader, who takes his words in their genuinely obvious acception, wherever the context doth not manifeſtly force another on them, (in which then the reader acquieſces) the writer is eaſily underſtood. But when nimble and foreſtalled wits peruſe an author, not to ſit down with his ſenſe, but to make him ſpeak theirs, (whether it be his own or no;) and giving themſelves the pains and leiſure of conſidering all the poſſible acceptions of a word or phraſe, and the liberty of pitching upon that which beſt ſerves their preſent turn, allow themſelves to conclude, that becauſe it may ſignify ſo and ſo elſewhere, therefore it does ſo here: an author muſt be much warier than *Homer* and *Virgil*, whom *Eudocia* and *Alexander Roſs* have made evangeliſts, to keep his words from being tortured into a confeſſion of what was never in his thoughts. And a very pregnant inſtance of this truth we may obſerve in the law of our land, whoſe very end being to prevent or aboliſh ſtrifes; and which being written ſo punctually and expreſly, and in ſo peculiar and barbarous a ſtyle (clogged with ſupernumerary repetitions) that nothing but their being conducive to ſo good an end could make it ſupportable; is yet by mens concerned wits ſo miſconſtrued and perverted, that not only in private mens caſes, we ſee the judges ſo puzzled, that ſuits oftentimes out-laſt luſtres; but the prince's party and the ſubject's kill, and execute one another; and (as charity tempts me to preſume) think they may do ſo by the law, and do ſo for the law. In this belief, that we often impute to the ſcripture our own faults and deficiencies, the inſtances of thoſe anti-ſcripturiſts, I have converſed with, have very much confirmed me: though I have ſtill eſteemed, that the beſt as well as the ſhorteſt way, is not to wrangle with them about every nicety, where the defeat of their objections gives us no victory over their incredulity, and by but evidencing the ſcripture's not being either falſe or abſurd, can ſerve but to juſtify our reverence to them, not to impart it; but by ſolidly aſſerting the divine origination of the ſcripture, reduce men to aſcribe their ſcruples to the true cauſe; and perſuade us to the temper of the Apoſtles, who, when Chriſt had uttered a hard ſaying, which ſo unſettled many of his diſciples, that they deſerted him upon it; though (their groſs miſapprehenſions of numerous other much leſs obſcure paſſages will eaſily perſuade us) they reliſhed it not aright, yet would by no means forſake him for their maſter, becauſe, ſays their ſpokes-man, *Peter, thou haſt the words of eternal life, and we be-* John vi. *lieve, and are ſure, that thou art the Chriſt,* 67, 68, 69. *the Son of the living God:* teaching us, with one grand and comprehenſive truth, to ſilence particular ſcruples. And one thing would not be unworthy our objectors conſidering; that the truth and authority of the ſcriptures, and conſequently their not being contradictory to themſelves, hath (as we may elſewhere have occaſion to manifeſt more at large) been immemorially believed by the learnedeſt men in the world; many of whom may be very reaſonably ſuppoſed to have examined opinions without any other concern in their inquiries than that of not being deceived; or any other end than that of finding out the truth; and moſt of whom, though by their ſedulouſneſs and their erudition they diſcovered difficulties in the bible, that our quæriſts could never have dreamed of; yet did they all conclude the belief of the ſcriptures grounded on as much reaſon, as is conſiſtent with a due latitude for the exerciſe of faith: which poſſibly needs ſome dimneſs or reluctancy in the underſtanding, to be an acceptable virtue of the will; (faith and the twilight ſeeming to agree in this property, that a mixture of darkneſs is requiſite to both; with too refulgent a light, the one vaniſhing into knowledge, as the other into day.) And now faith thus caſually preſents her ſelf in my way, it will, perhaps, not be impertinent to obſerve, that Chriſt often deals with new believers, as he is recorded to have done with *Nathaniel*; for as when that guileleſs *Iſraelite* had acknowledged him the Meſſias, upon the bare evidence of his having been diſcerned by him under the fig-tree, our bleſſed Saviour tells him, *Becauſe I ſaid unto thee, I ſaw thee under* John i. *the fig-tree, believeſt thou? Thou ſhalt ſee grea-* 50. *ter things than theſe*; (which in the next verſe he proceeds to mention:) ſo when men once have embraced the perſuaſion of the ſcripture's being divinely inſpired, that faith is a thing ſo acceptable to God, that he often diſcovers to them, to confirm them in their belief, arguments much clearer than thoſe that induced them to it; and convinces them of the reaſonableneſs of having ſubmitted their reaſon to him that gave it them. And, (as if there were myſteries, in which faith doth more proſperouſly make way for underſtanding, than that is ſet awork to introduce faith,) it happens to them, as it did to the two blind men Matth. ix. mentioned in the goſpel, in whom our Saviour 27, &c. firſt required faith, and (having found that, he) then opened their eyes.

The ſeventh OBJECTION.

FROM the (not long ſince mentioned) frequent repetitions to be met with in the ſcripture, and from the unuſual method, wherein the author of it has thought fit, that the divine truths and precepts ſhould be extant there, divers

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divers have been pleaſed to take occaſion to criminate the bible, as if, its bulk conſidered, it were but a barren book; wherein inſtructions are but ſparingly ſcattered, in compariſon of what is to be met with in divers other writings, where repetitions are avoided, and more of uſeful matter is delivered in fewer words. And hence it is (ſay theſe objectors) that many perſons unqueſtionably religious chuſe rather to ſtudy other books of devotion and morality, as containing more full and inſtructive precepts of good life.

I MIGHT anſwer this allegation by repreſenting, that the ſeveral particulars, whereon the accuſation is grounded, having been already examined by me, I need not ſay any thing diſtinctly to this accumulative charge. But becauſe I would not only defend my veneration for the ſcripture, but perſuade it, I ſhall on this occaſion offer two or three things to conſideration.

ALTHOUGH then the ſcripture were leſs repleniſhed with excellent doctrines, and were but, as well as the beſt of other books, like mines, in the richeſt of which the golden ore is mingled with ſtore of precious materials, (and needs a laborious ſeparation from them;) yet ſure it would, like thoſe mines, deſerve to be carefully digged in: and it will become the grateful Chriſtian's zeal to imitate him in the parable, who having found *a treaſure hid* Mat. xiii. 44. *in a field*, ſtuck at no price within his power, to purchaſe the whole field for the treaſure's ſake.

BUT, God be praiſed, this is not the caſe; for it is only our ignorance, our lazineſs, or our indevotion, that keeps us from diſcovering, that the ſcripture is ſo far from being, as the objectors would have it, a wilderneſs or a barren ſoil, that it may be much more fitly compared to that bleſſed land of promiſe, which is ſo often ſaid in ſcripture to be flowing with milk and honey, things uſeful and delightful; if not to paradiſe itſelf, of which, it is ſaid, Gen. ii. 9. that there *the Lord God made to grow every tree, that is pleaſant to the ſight, and good for food; the tree of life alſo in the midſt of the garden.* And indeed, as the author of it was omniſcient, ſo experience has taught, that he has ſo much expreſſed himſelf to be ſo in the ſcripture, that the more knowing its pious ſtudiers have been, the greater ſtore of excellent truths they have met with in it; the ſcripture being indeed like heaven, where the better our eyes and teleſcopes are, the more lights we diſcover. And that this may not appear to be ſaid *gratis*, let us conſider, that a book may be inſtructive as well by teaching its readers ſpeculative truths as practical ones, and that Chriſtians ought as well to know what God would have us think of him and his works, as what he would have them do. Now as it is paſt queſtion, that there are no ſpeculative truths, of ſo noble and elevated a nature, as thoſe that have God himſelf for their object; ſo there is no book, from whence there is ſo much to be learned, as there is from the bible, of the nature, and even the thoughts of God, and of thoſe deep myſteries, 1 Pet. i. 12. into which, as I formerly noted from St. *Peter*, the angels themſelves are greedy of prying. Nay, there is no other book whatſoever, that teaches us any thing at all, concerning divers of theſe ſublime ſubjects, that may be ſafely relied on, ſave in what it is beholden to the ſcripture for. So that we cannot without an extreme injury look upon that book as barren, which alone contains all thoſe revealed truths, which are of ſo noble and precious a nature, that we juſtly prize the compoſures of heathen philoſophers, and other authors, for being inriched with gueſſes at ſome few of them, though much embaraſſed by the alloy, whereto the truths, conjecturally delivered, are made liable from the imperfections of writers, always fallible, and, for the moſt part, in ſome degree or other, actually erroneous. But of this more perchance elſewhere. Wherefore I ſhall now add, that whereas thoſe we reaſon with, are pleaſed to prefer other books of morality and devotion before the ſcripture, in reference to good life; they would probably be of another mind, if they duely conſidered, that to engage men to live well and holily, there is much more requiſite, than barely to tell them, that they ought to do ſo, and how they ſhould do it. For ſince to lead a life truly virtuous requires in many caſes, that we deny and overcome our natural appetites and inclinations, and requires alſo conſtancy in a courſe, that is confeſſedly wont to be attended with many hardſhips and dangers; it is not ſufficient, to engage a man to a good life, to give him precepts of it; which do not ſo much (what is yet the main thing in this caſe) make men willing to conform to ſuch precepts, as ſuppoſe them ſo. And he, that can do no more, does far leſs than him, who, beſides the rules of good life, preſents men the higheſt, and the moſt prevalent motives to embrace piety and virtue, and the moſt powerful diſſuaſives from all that is wicked; by propoſing to us ſuch rewards and puniſhments, and ſatisfying us, that we ought, according as we behave ourſelves, to expect either the one or the other; as to convince us, that we cannot be either wiſe or happy, but by being good, nor avoid the greateſt of miſeries, but by avoiding vice. Now, as we ſhall ſee anon, that as to the precepts of good life, the bible is not unfurniſhed with them; ſo as to that moſt operative part of the way of teaching good life, the propoſing of the moſt prevalent motives to good, and the moſt powerful diſſuaſives from evil; not only no other book does, but no book not inſpired, can perform, in that kind, any thing near ſo much as the ſcripture alone. Since we have not the ſame reaſon to believe any mere man, as we have to believe God, touching thoſe rewards and puniſhments, which he reſerves after death for thoſe, that conform to, or diſobey his laws; theſe being matters, which (whatever philoſophers and other learned men may have thought to the contrary) depend upon his free will, and conſequently are not to be explicitely known but by his revelation; which he has not, that appears, vouchſafed us in any other book than the ſcripture. And therefore it is not to be wondered at, that St. *Paul* ſhould

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aſcribe it to our Saviour Chriſt, *That he had*
2 Tim. i. 10. *brought life and immortality to light through the goſpel.* And whereas hope is that ſpur, without which men do ſcarce ever cheerfully undertake, and reſolutely go through things, much leſs difficult and dangerous than thoſe, which a virtuous courſe of life is wont to expoſe men to, St. *Peter* makes a Chriſtian's higheſt hope to depend upon a revealed truth, where he gives thanks to God for having, *ac-*
1 Pet. i. 3. *cording to his abundant mercy, begot us to a lively hope, by the reſurrection of Jeſus Chriſt from the dead.* And what influence ſuch a knowledge of God and Chriſt, as, if we have it at all, we muſt owe to the ſcripture, and ſuch hopes and promiſes, as none but God himſelf, or thoſe he ſends, can give a wary and intelligent perſon, may have upon good life, you may gueſs by that other paſſage of the ſame Apoſtle, where not only he mentions God's
2 Pet. i. 3, 4. having *according to his divine power* (or efficacy) *given unto us all things, that pertain unto life and godlineſs, through the knowledge of him, that hath called us to glory and virtue*, but alſo immediately after ſpeaks of our being made *partakers of the divine nature*, and *eſcaping the corruption, that is in the world through luſt*; by thoſe exceeding great and precious promiſes, that are given of God unto us. So that although the ſcripture did not expreſly give us ſuch moral documents as ethical writers do, and taught us good life, but by acquainting us with what God has revealed in thoſe writings concerning himſelf, and by convincingly propoſing to us thoſe higheſt inducements to embrace a good, and ſhun an evil life, which (though reaſon may perchance make ſome weak and confuſed gueſſes at them,) revelation only can make examining men confidently depend upon: if, I ſay, the ſcripture did no more than thus engage us to reſolve upon a good life, leaving us to derive the particular precepts of virtue from the inward dictates of the law of nature, and the exerciſe of our own reaſon, (which two together may well teach us almoſt as much as ethical books are wont to teach, of really and conſiderably uſeful) the ſcripture ought yet to be eſteemed a moſt inſtructive book in reference to good life. As in effect we ſee, that the writings of no philoſopher or orator ever made any thing near ſo many perſons ſo virtuous, as the new teſtament, though but a pocket book, has been able to do; eſpecially in thoſe primitive ages of the church, when thoſe that received that book were leſs diverted from it, than ſince they have been by the reading of others. The moon may in clear weather lend a gardener light enough to dig, and manure his orchard, and perhaps to prune his trees; but none will ſay, that the moon does as much contribute to his labouring to produce fruit as the ſun; ſince this nobler planet not only affords him light to work by, and a comfortable warmth whilſt he is working, but animates him by the hopes he cheriſhes upon the ſun's account, that in due ſeaſon his diligence and toils ſhall be rewarded. The application is too obvious to need to be inſiſted on.

BUT though upon the fore-mentioned accounts alone, the ſcripture would deſerve to be looked upon as highly conducive to the practice of piety, and virtue; yet it is far from being true, that it is deſtitute of ſuch moral documents, which it needs not, to deſerve to be looked upon as a book very inſtructive in reference to good life. For there being two ſorts of virtues requiſite to an embracer of the goſpel, which have been conveniently enough called, for diſtinction-ſake, the one Chriſtian, and the other moral or ethical; I ſuppoſe it will not be doubted, but that the rules of thoſe virtues, that are properly Chriſtian, muſt be ſought for in the ſcripture, that being acknowledged by proteſtants, to have ſuch a ſufficiency as to matters of meer revelation, (which reſtriction too many do inconſiderately enough leave out) that in matters of that nature, divines often do, and in many caſes may, argue negatively, as well as affirmatively from the ſcripture; which eaſes us of many things obtruded as duties, merely by its not, either expreſly, or by conſequence, impoſing them upon us. So that as to things of this nature, there is ſuch a fulneſs in that book, that oftentimes it ſays much by ſaying nothing, and not only its expreſſions but its ſilences are teaching, like a dial, in which the ſhadow as well as the light informs us. Nor muſt we think, that the bible is deſtitute of the beſt ſort of ſuch precepts, exhortations, and diſſuaſives, as we prize in ethical books; becauſe they are not expreſſed and ranged in the bible, as they are wont to be in ſyſtematical compoſures; for not only there is extant in the ſcripture, to them that know how to conſtellate thoſe lights, a very excellent body of moral precepts; but there are likewiſe ſcattered the forcibleſt motives to the ſeveral duties, and the moſt retracting diſſuaſives from the contrary vices. And truly, it hath long leſſened my eſteem of our heathen morals, that ethicks being but the doctrine of regulating our paſſions, and directing our faculties, in order to the attainment of felicity, they have been hitherto handled by thoſe, to whom the nature of the faculties and paſſions of the mind was but very little known: whereas to the author of the ſcripture morals, the frame and ſprings, and faculties of our ſouls, being intuitively and moſt perfectly known, the moſt proper and powerful ways of working on them, cannot be unknown to him: and then certainly, one unacquainted with the trade will be much leſs likely to mend a watch, that is out of order, than a watch-maker. And indeed, even in reference to that other ſort of virtues, which are wont in the more confined ſenſe of the word to be called moral, there are I know not how many excellent notions and directions, relating to them, diſperſed up and down in the ſcripture; though by reaſon of their not being drawn up by themſelves, and of their being mingled with other matters, they are not ſo readily taken notice of by ordinary readers. Whereas, thoſe ſtudious peruſers, that ſearch the ſcriptures with a due diligence and attention, are not only wont eaſily enough to deſcry the moral counſels and preſcriptions

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over-looked by the other readers; but take notice of many excellent documents, that are plainly enough intimated or hinted there to knowing and diligent perusers, though not clearly and expresly enough to be found of those, that think them not worth seeing.

WHEREFORE, as to those religious persons mentioned in the last proposed objection, I cannot but think, that by neglecting the scripture for ethcial compositures, or even books of devotion, they as well wrong themselves as the scripture; and therefore I shall take leave to think the worse, rather of the practice of the men, than of the book of God. Scarce any thing has given me a favourabler character of *Luther*, than his wish, that all his books of devotion were burnt, when he once perceived, that the people's fondness and over-valuation of them produced a neglect of the study of the bible; to which you shall find, *Theophilus*, that the best of that nature being compared, are but (not to draw to our present purpose that of *Seneca* to his mother; *Paribus intervallis omnia divina ad omnibus humanis distant*) like the stars compared to the sun, whose emanations confer on them their lustre, but whose presence drowns it. For though I deny not books of devotion a due degree of praise and usefulness, yet I refuse them the superlative degree of either; and since the writers of the best of that kind of compositures, either steal their best things from, or acknowledge that they borrowed them of the bible; I would not have Christians neglect the fountain for the streams, and unwisely, as well as unthankfully, elect to read God's word, rather in any book than his own; in which, to encourage us to study the precepts of a virtuous and holy life, we have such peculiar and encouraging invitations.——Saint *Paul* seems to make it the (end and the) result of the several usefulnesses he attributes to the scripture, *That it can make the man of God perfect, thoroughly furnished unto all good works*; *and is able*, (as he speaks a little higher) *Σοφίσαι εἰς σωτηρίαν, to make us wise unto salvation.* There are indeed many excellent instructions given to us in other books; but they giving us directions, only towards the attainment of the advantages, conveniences, and ornaments of life; the ignorance of them only makes us miss those particular ends, whereto they give addresses, or whereof they facilitate our pursuits; but the knowledge, whose acquist, or neglect, imports endless joys or torments, we need seek only from the scripture: a Christian to understand the duty of his faith and life, needing to understand no other book than the bible; though indeed to understand the bible well, it is ordinarily requisite, that a pretty number of other books be understood. Christians then have reason to study most that book, which understood, all others are needless to salvation, and which ignored, they are insufficient. If Saint *Peter*'s vision had been a reality, he would scarce, hungry as he was, have ranged abroad to hunt in this desart or that forest for game, when he had a vessel let down to him from heaven, containing in it's self all manner of four-footed beasts, and other objects of appetite, attended with a commanding invitation from heaven, *Rise*, Peter, *kill, and Eat.* So when God sends us from heaven in one volume, a, at least virtual, collection of all those divine truths and holy precepts, others scatteringly and sparingly glean out of human books; the Christians cannot but prize a book so comprehensive, which by making it safe for him to ignore others, by so merited an *Antonomasia*, wears the title of *the book*, (for so the bible signifies in Greek, as the Hebrews call it *Mikra*, which by excellence signifies *what's to be read.*)——There are precepts enough of virtue, and motives enough to conform to them, held forth in the bible, if the contents of that divine book were believed and considered as they ought to be. It is a mistake to think, that a large system of ethicks, dissected according to the nice prescriptions of logick, and methodically repleniſhed with definitions, divisions, distinctions, and syllogisms, is requisite or sufficient to make men virtuous. Too many of our moralists write, as if they thought virtue could be taught as easily, and much in the same way, as grammar; and leaving our rational motives to virtue, and determents from vice, with other things, that have a genuine influence on the minds and manners of men, they fall to wrangle about the titles and precedences of the parts of ethical philosophy, and things extrinsecal enough to vice and virtue; they spend more time in asserting their method, than the prerogatives of virtue above vice; they seem more sollicitous, how to order their chapters than their readers actions; and are more industrious to impress their doctrine on our memories than our affections, and teach us better to dispute of our passions than with them. Whereas, as the condition of a monarch, who is possessed but of one kingdom or province, is preferable to that of a geographer, though he be able to discourse theorically of the dimensions, situation, and motion, or stability of the whole terrestrial globe; to carve it into zones, climates and parallels, to enumerate the various names and etymologies of its various regions, and give an account of the extent, the confines, the figure, the divisions, *&c.* of all the dominions and provinces of it: so the actual possession of one virtue is preferable to the bare speculative knowledge of them all. Their master *Aristotle* hath herein been more plain, and less pedantick; who (by favour of his interpreters) hath not been nice in the method of his ethicks. And indeed, but little theory is essentially requisite to the being virtuous, provided it be duly understood, and cordially put in practice; reason and discretion sufficing, analogically, to extend and apply it to the particular occurrences of life; (which otherwise being so near infinite, as to be indefinite, are not so easily specifiable in rules:) as the view of the single pole-star directs the heedful pilot, in almost all the various courses of navigation. And the systems of moralists may (in this particular) not unfitly be compared to heaven, where there

Seneca de Consl. ad *Helviam*, cap. 9.

2 Tim. iii. 17.

Ver. 15.

Acts x. 11, 12, 13.

Mikra, *Lectio.*

there are luminaries and ſtars obvious to all eyes, that diffuſe beams ſufficient to light us in moſt ways; and as I, that, with modern aſtronomers, by an excellent teleſcope, have beheld perhaps near a hundred ſtars in the *Pleiades*, where common eyes ſee but ſix; and have often diſcerned in the milky-way, and other pale parts of the firmament, numberleſs little ſtars generally unſeen, receive yet from heaven no more light uſeful to travel by, than other men enjoy: ſo there are certain grand principles and maxims in the ethicks, which both are generally conſpicuous, and generally afford men much light and much direction; but the numerous little notions, (admit them truths) ſuggeſted by ſcholarſhip to ethical writers, and by them to us, though the ſpeculation be not unpleaſant, afford us very little peculiar light to guide our actions by. When I remember thoſe ancient heroes, that have ennobled ſecular, and are ennobled by ſacred ſtory, and whoſe examples ſuggeſted the precepts of virtue, before there were any written ones to conform to; I am tempted to ſay, that virtue was ſcarce ever better practiſed, than whilſt men had not yet talked of the definition of it: (as many an alchymiſt begs with rare notions of the nature of gold, which fills the coffers of merchants, that never ſaw mine nor furnace.) The grand precepts of morality are fruitful ſeeds, which, induſtriouſly cultivated, will bring forth fruits ſtill affording other ſeeds. And as for the motives to pious, and diſſuaſions from ſinful practices, though out of the many voluminous books of morality, there may be divers collected, not extant in the bible; yet may a dextrous reader find in that heavenly book many more invitations to virtue, and determents from vice, than moſt men are aware of; and ſome of them of an importance, that renders one of them as much more conſiderable than many ordinary ones, as one fair pearl out of a jeweller's ſhop out-values a ſcore of thoſe little pearls, that druggiſts ſell by the ounce, or doth comprize many inferior inducements, (which wiſe men judge not of by tale, but value) as a piece doth twenty ſhillings. And though human authors do often in their parenetical treatiſes allow themſelves to be laviſh in ornaments, to expatiate into amplifications, and to drain common-places; yet whilſt they want an intimate admiſſion, all theſe are too often unable to reform, I ſay not thoſe that read them, but even thoſe that write them: whereas the experience of the primitive and heroical ages of the church does glorioufly manifeſt, that the inducements and diſſuaſives held forth in the bible, though deſtitute of thoſe embelliſhments and advantages, where they are conſcionably entertained, and ſeriouſly pondered, are ſufficient to raiſe virtue to a pitch philoſophy durſt ſcarcely aim at. Nor indeed is the number great of pertinent and rational incitements, or determents, relating to virtue; and in diſcourſes, that have them for theme, how far ſoever the bows may extend, yet generally the knot lies in a little compaſs: and the analyſer, that ſhall crack many of thoſe compoſures, having ſever'd the ſhells, ſhall find their kernels to be much alike. What this writer compares to one thing, that writer likens to another; thoſe ungrateful perſons to God, that one reſembles to ſwine, who eat the acorns without ever looking up to the tree they fall from, another compares to cattel, that drink of the ſtreams, without conſidering what fountain they flow from; theſe but preſent us ſeveral dreſſes of virtue and vice, where though the novelty and variety of habit ſerve to engage attention in all, and want not influence (at leaſt) upon eaſy and flexible natures, yet in conſiderate and diſcerning perſons, they alter not much the notion, under which the qualities themſelves are entertained. Nor will ſuch be apt to quarrel with the author of the ſcripture; becauſe the motives and diſſuaſives extant there are many of them old and known, or frequently repeated; the efficacy of them being ſo too. Were it not ſtrange, a phyſician ſhould decline exhibiting of mithridate, becauſe it was a known medicine, and famous for its cures many ages ſince? Doth bread leſs nouriſh us, or is it leſs uſed, becauſe it was (as men ſuppoſe) contemporary to *Adam*, and the moſt common food of all nations in all ages? And (as to the repetition of the ſame allegation and inducements, as often as men's condition returned to need them) the paucity of ponderous conſiderations in the ethicks often neceſſitating either (diſguiſed perhaps, yet) repetitions of the ſame, or the ſubſtitution of thoſe, that muſt be much inferior to be new; ſuch perſons as little admire, that reiterated employment of the ſame truths, as they would to ſee a ſoldier uſe a ſword, though he, and legions many ages before him, have conſtantly made moſt uſe of that weapon; or a general encourage his engaging ſoldiers by repreſenting to them honour, duty, ſpoil, neceſſity, and thoſe other known topicks uſed by himſelf at the head of his army, as often as he had occaſion to lead it on to fight. To all this I am invited by this occaſion to ſubjoin, that upon the ſcore of God's being both an omniſcient ſpirit and the ſupreme law-giver to the whole creation, the ſame truths, counſels, exhortations, diſſuaſions, *&c.* oftentimes have, and always ought to have, another-gueſs efficacy and prevalence on a Chriſtian reader, when he finds them in the ſcripture, than if he ſhould meet with the ſame in the books of heathen moraliſts, though learned and eloquent. And certainly, thoſe, that with ſuch reverence read the writings of thoſe great wits of antiquity, that have made the greateſt diſcoveries of truth, becauſe they believe them to have been endowed with very illuminated intellectuals, ought to pay them, and a book publiſhed by an omniſcient enditer, a reverence ſomewhat proportionate to the diſparity of their authors, ſince men (as *Elihu* ſpeaks in *Job*) *are but of yeſterday, and know little or nothing*. A wary perſon reads the wiſeſt authors, with a reflection, that they may deceive him by being themſelves deceived; and undergoes a double labour, the one in inveſtigating the meaning, and the other in examining the truth of what they deliver: but in the bible, we are eaſed of the

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the latter of theſe troubles; for if we find the ſenſe of a text of ſcripture, we cannot miſs a truth, being never deceived by that book, but when we deceive our ſelves by preſuming we underſtand it, when indeed we do not. I am otherwiſe affected to find the vanity of the world proclaimed and depreciated by him, that enjoyed all the delights and glories of it, than when I meet with the ſame truth from ſome beggarly Cynick, that never was admitted to taſte thoſe luſcious and bewitching pleaſures, and needs no great philoſophy to deſpiſe a world, he judges of by the ſcant ſhare the narrowneſs of his condition allows him of the joys of it, and of which (conſequently) his criminations ſhould as little move, as a blindman's of a black-moor; whom though he may (perchance) truly ſtyle ugly, yet he were of a ſomewhat eaſy faith, that ſhould think her ſo, barely upon the teſtimony of ſo incompetent a witneſs. Thus when God himſelf is pleaſed to reveal, what is vice or virtue, ſublime or deſpicable, truth or falſhood, happineſs or miſery, I have another-guiſe acquieſcence in his deciſions, than in the ſame met with in an human author, who having neceſſarily frailties and paſſions, is both obnoxious to miſtake, and capable to deceive. And therefore it is no wonder, that the ſlighting of God's dictates ſhould receive an aggravation upon the ſcore of their being his; as our Saviour gave the precedency of the Ninivites converted by *Jonah* to them, that repented not at his preaching, becauſe he was *a greater than Jonah.* And therefore, though I have formerly been no very negligent peruſer of books of morality; yet knowing, that they have a power but to perſuade, not to command, and that the penalties of ſin or death are not inſeparably annexed to the diſobedience of their preſcriptions, I confeſs, I often find my ſelf but faintly wrought on by them. For I muſt acknowledge, that frequently aſſuming the liberty of queſtioning the reaſonableneſs of what human writers, (whether philoſophers or fathers) are pleaſed to impoſe upon us; I find thoſe ſpecious and boaſted allegations, the apothegms of the ſages, the placits of the philoſophers, the examples of eminent perſons, the pretty ſimilies, quaint allegories, and quick ſentences of fine wits; I find all theſe topicks I ſay, ſuch two-edged weapons, that they are as well applicable to the ſervice of falſhood, as of truth, and may by ready wits be brought equally to countenance contrary aſſertions. And really, moſt moraliſts, except in thoſe few duties, that nature herſelf hath fore-taught us, to a man, whoſe reſtleſs curioſity leads his enquiries to all times and nations, will appear little other than fencers with wit, (I mean thoſe that have any;) for each of theſe popular topicks is ſuch an unſolid or uncertain foundation, that one man can build a little on it, that an equally able antagoniſt may not with as ſpecious probability overthrow; and I fear, moſt of us have but too often found our corruptions ſophiſters enough to elude any ſuch thing, that preſſed that as a duty, which they had no mind we ſhould perform. But when I find any thing enjoined in the ſcripture, my conſciouſneſs to its being impoſed by that *father of ſpirits,* (who has both right to enact laws, which muſt be therefore juſt, becauſe he enacts them, and power to puniſh the tranſgreſſion of them, with no leſs than eternal death;) I then leave roving, and ſee where to caſt anchor. I think it my part without diſputing them to obey his orders, and acquieſce more in that imperious ἄνλω ἔφη, *Thus ſaith the Lord,* than in a whole dialogue of *Plato,* or an epiſtle of *Seneca.* I therefore love to build my ethicks (as well as my creed) upon the rock, and eſteeming nothing but the true, proper, and ſtrict ſenſe of the ſcripture, (and what is convincingly deducible from it) to be indiſpenſably obligatory, either as (in matters of mere revelation) to faith or practice; it is no wonder, if I ſtudy God's will moſt in that book, wherein alone I think it revealed; and, truly, finding in my ſelf no motive more juſtly prevalent to obedience, than his right to exact it that requires it, few men are more ready than I, in diſtinguiſhing what indeed God ſays from what man would make him ſay. And if I allow my ſelf ſuch liberty to diſcern the text from the gloſs, in the writings of our vulgar interpreters, (of moſt of whoſe comments, for reaſons proſecuted into another paper, I am no great idolater) and even of the fathers of the church; I hope I ſhall not need to tell *Theophilus,* that in all other moraliſts I like the freedom to like or diſapprove, as upon examination my impartialeſt reaſon reliſhes them, or that I frequently fear their harangues will hardly paſs for demonſtrations, with thoſe wary teſters, that like not to be cheated, ſo much as into virtue, but chuſe to act as rational or Chriſtians, as well in relation to the inducements, as to the nature of what they do.

Mat. xii. 42.

Heb xii 9.

AMONGST the thirteen articles of the Jewiſh creed, one acknowledges the very expreſſions of the law (or pentateuch) to have been inſpired by God. That ſaying of the Rabbins is not altogether ſo hyperbolical, as a perfunctory reader would imagine, that upon each title of the law whole mountains (of doctrine) hang. I ſhall not mention, as any proof of this, the ſtrange myſteries they fancy in the ſtrange accenting of the ten commandments in the original, ſince their ſoberer doctors have in free diſcourſe confeſſed to me, that it is as much a riddle to them as us. Nor ſhall I inſiſt upon the Jews reducing the whole law to 613 precepts, affirmative and negative, according to the number of the letters of the decalogue; thereby inſinuating, that all the laws, that regulate man's duty, are virtually or reductively comprized there. Although this Rabbinical notion, (not to call it whimſey,) be in ſuch requeſt among them, and ſo known to thoſe, that are any thing converſant in Jewiſh authors, that I have ſometimes ſuſpected, that the conceit entertained by ſo many Chriſtian divines, that all the precepts, that relate to any part of the whole duty of man, are but juſt conſequences deducible from the decalogue, had its riſe thence. But I ſhall not, as I ſaid, ground my opinion of the pregnant inſtructive-

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inſtructiveneſs of the ſcripture, upon ſuch queſtionable, not to ſay altogether proof-leſs, conceits. That which may better perſuade a conſidering man, is, that beſides thoſe more reſplendent and obvious truths, wherewith the ſcriptures do evidently abound, there are many inſtructions exhibited, many truths aſſerted, many errors confuted, and many myſteries hinted, in the very expreſſions of holy writ, to an inquiſitive and concerned peruſer, which a heedleſs vulgar reader is not wont to take notice of. God, who in the ſcripture is ſaid *to cover himſelf with light as with a garment*, juſtifies that expreſſion in the ſcripture, where (as the firſt words, that he is recorded to have ever ſpoken, were יהי אור Yehi-or, *Let there be light*) the very words and phraſes, that cloath the ſenſe, are not alone emphatical, but oftentimes myſterious. The Apoſtle aſſures us, *whatſoever things were written*, even in the old teſtament, *were written for our learning*; but yet, beſides thoſe many particular ſentences of the bible, that are not deſtitute of inſtructions, there are ſome ſo pregnant with them, that we may eaſily find this difference betwixt them and human writings, that thoſe firſt mentioned contain more matter than words, and the other more words than matter. Nay, many of the very flowers of rhetorick growing there have (like the marygold, that in hot countries points at the ſun) a virtue of hinting the uſefulleſt and the ſublimeſt truths; the bible being in this like the tree of life, (flouriſhing in the *New Jeruſalem*) which not only afforded ſeaſonable fruit, but of which the very *leaves were for the healing of the nations*. As for thoſe, who have in this and the laſt age made bold to depreciate the old teſtament, by pretending, that to Chriſtians the view is ſufficient; I am at preſent apt to think, that the doctrine of the goſpel, together with the light of nature, (which it excludes not) but rather ſuppoſes, contains all thoſe duties, which are abſolutely neceſſary to be perform'd by all Chriſtians, in order to ſalvation. And that conſequently, many divines, both Catholicks and Reformed, do inconſiderately enough preſs many things enacted in the old teſtament, as laws properly ſo call'd, which are not now, upon the ſcore of their being there enacted, obligatory to us Chriſtians, nor perhaps ever were to any, but the Jews, and ſome kind of Jewiſh proſelytes. But I think withal, that though it be hard to ſhew, that any thing is a neceſſary duty to Chriſtians, in the ſenſe above declared, if it cannot be ſhewn to be ſo, either by the new teſtament, or the light of nature: yet not only there are many particulars relating to ſuch duties, of which the old teſtament may excellently aſſiſt us to give ourſelves a more diſtinct and explicite inſtruction, than is eaſy to be collected from the new; but of the myſteries of our religion, there are many things deliver'd more expreſly, or more fully, in ſome paſſages of the old teſtament, than in any of the goſpel, as I could eaſily evidence, if I thought it requiſite. So that the uſe of it is very great, as to the *credenda* in divinity, though not perhaps abſolutely neceſſary as to the *agenda*. But I conſider further, that both the matters and the expreſſions made uſe of in the old teſtament are ſo very frequently, and, almoſt upon all occaſions, related to in the new, (as if the wiſdom of God were like rivers and ſeas, that affect to flow in the ſame channels themſelves had made before) that there is ſcarce a page of the latter, to the better underſtanding of which the ſtudy of the former is not either abſolutely neceſſary, or at leaſt highly uſeful. Should God be pleaſed to inſtruct us, as he did *Jonas*, by the ſhadow of a weed, it were our duty to acquieſce: how much more then, when he vouchſafes to ſpeak to us in almoſt as glorious a manner as he did to *Moſes*; in a ſcripture, that hath ſuch reſemblances to the ſanctuary, which contained the law of God, exhibited the mercy-ſeat, (the type of Chriſt) and wherein the two golden cherubims, like the two precious and harmonious teſtaments, looked towards one another, and both towards that mercy-ſeat, that typified the Meſſias? We ſhould therefore, not only with acquieſcence, but gratitude, look upon God's having appointed the ſcripture to be the light, in which his ſpirit regularly ſhines upon his church; ſince the luminary is as well refulgent, as the choice of it his, whoſe bleſſing can proſper any means of grace, as without his bleſſing no means of grace can proſper.

Pſalm civ. 2. Gen. i. 3. Rom. xv. 4. Rev. xxii. 2. Jonah iv. 6. Exod. xxv. 16, 17, 18, 19, 20, 21, 22.

AND, *Theophilus*, ſince among thoſe, that are ſo far miſtaken, as to poſtpoſe the ſtudy of the bible to that of ſome applauded books of morality and devotion, there are not wanting divers perſons, otherwiſe eminently religious; I hope you will eaſily excuſe me, if, for fear their example ſhould prove a temptation to you, and add to the diſcouragements you muſt expect from the darkneſs of ſome texts, and the oppoſition, that will be given you, eſpecially at firſt, by the grand enemy to the author and deſign of the ſcripture; I venture to ſuperadd to all that I have ſaid already, concerning theſe mens practice, that it is not only a commendable, but a much more improving cuſtom, than it is by many thought, to read daily and orderly ſome ſet portion or chapters of the bible; and, not to deſiſt from that practice, though (as *Naaman* dipped himſelf ſix times in *Jordan*, without being cured) we ſhould not perceive a ſudden and ſenſible benefit accruing from it. For in diſeaſes (bodily or ſpiritual) though the mouth be out of taſte, and cannot reliſh what is taken in, yet wholeſome aliments muſt be eaten, and do effectively nouriſh and ſtrenghten, though they be then inſipid, (perhaps bitter) to the diſtempered palate. We muſt, with the eunuch, read divers texts we underſtand not, when we read them; and though, at firſt, we be not able to penetrate the ſenſes of ſome portions of God's word, we muſt at leaſt make our faculties as hoſpitable to it as we can; and make our memories admit, and embrace it, till our underſtandings be grown up to do the like: it becoming the diſciples of our Saviour, herein to imitate his holy mother, of whom it is written, that *they* (the bleſſed virgin and her huſband) *underſtood not the ſayings, which he ſpake*

2 Kings v. 14. Acts viii. 30, 31. Luke ii. 50, 51.

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Sever. 18. *ſpake unto them,* ——— *but his mother*
19 *kept all theſe ſayings in her heart*; and to
John xiii. think it may very well be, that, as our Sa-
7. viour ſaid to *Peter*, *What I do, thou knoweſt not now, but thou ſhalt know hereafter:* ſo, by the welcome he diſpoſes you to give his word into your memory, he ſays to you, *What I ſay, thou knoweſt notnow; but thou ſhalt know hereafter:* and the apoſtle's motive to hoſpi-
Heb. xiii. 2. tality, *Be not forgetful to entertain ſtrangers, for thereby ſome have entertained angels unawares*, will, without being overſtretched, take in the texts of ſcripture we are unacquainted with. For we may eaſily in them, entertain
Gen xviii. *and* Gen. xix. with *Abraham* and *Lot*, greater gueſts than we are aware of; and who, when their true condition appears, may recompence our entertainment of them, by ſhowering bleſſings on us, and reſcuing us from the company and deſtiny of the wicked. And ſure, if the Pagans laid up, with awful reverence, thoſe dark and ſquinting oracles, that came (at leaſt many of them) from the prince of darkneſs, and father of lyes; we ſhould bluſh to refuſe attentive peruſals, and lodging in our memories, to
Acts vii. 38. Rom. iii. 2. James i. 17. thoſe λόγια ζῶντα, thoſe *lively oracles*, thoſe λόγια τῦ Θεῦ, *oracles of God*, who is the father of lights, and an eſſential truth that cannot lye. And the moſt ænigmatical texts we meet
Tit. i. 2. with, which ſeem meant purpoſely to poſe us, we may make uſeful admonitors of our weakneſſes, and take for welcome opportunities, to evince how great a reverence we pay God's word, upon the ſingle ſcore of its being ſo. Nor let thoſe diſturbances, with which the devil ſeldom fails to obſtruct or diſcourage our firſt progreſs in a ſtudy ſo ruinous to his malicious ends upon us, deter us; for theſe are commonly but the throws and ſtrugglings of Chriſt new-formed in us; or elſe like thoſe horrid fits and outcries, which preceded the ejection of that unclean ſpirit mentioned in the
Mar. i. 26. firſt of *Mark*; ſuch parting ceremonies being not unuſual to the diſlodging devil; who when he finds himſelf upon the point of being ex-
Rev. xii. 12. pelled, *hath great wrath, becauſe he knoweth he hath but a ſhort time. And though the God*
Rom. xvi. 20. *of peace*, however he *will bruiſe Satan under your feet ſhortly*, ſhould for a while try us even with deſertion in the ſtudy of the ſcripture; let us not, for all that deſert ſo improving a ſtudy, but reſolutely perſevere in the conſtant and faithful uſe of the means of grace: as the moon, when ſhe ſuffers an eclipſe, forſakes not her orb or motion, but, by continuing her unretarded courſe, regains the irradiations ſhe was deprived of. We find the word of God compared to ſeed, (that deathleſs ſeed, by
Mat. xiii. 19, 20, &c. 1 Pet. i. 2, 3. which Saint *Peter* ſaith, we are *born again*) and that, we know, may ſeem, for a long time, as well dead as buried in the ground, and yet afterwards ſpring and grow up into a plentiful harveſt. Nor muſt our proficiency any more diſpenſe with us from the being converſant
Pſal. cxix. 93. with the ſcripture, than our frailties: *I will never*, (ſaith the Pſalmiſt) *forget thy precepts, for with them thou haſt quickened me.* And indeed, the word of God is not to be uſed like active phyſick, taken once, that it may not be taken again; but 'tis compared to food, which 1 Pet. ii. 2. indeed it is, of the ſoul; in which ſenſe it may *and elſewhere.* be literally enough ſaid, *That man liveth not* Mat. iv 4. *by bread alone, but by every word that proceedeth out of the mouth of God.* Now as our having fed never ſo well and heartily on excellent and nutritive meats yeſterday, will not keep us from needing to eat again to-day, or to-morrow, and ſo daily, as long as we continue in theſe ruinous cottages of clay; ſo in ſpiritual refec- Job iv. 19. tions with full, without repeated meals, the ſoul will ſcarcely thrive. And as, generally, the more healthy and luſty men are, the frequenter and ſtronger appetites they have; ſo the beſt Chriſtians, and (witneſs *David*) the greateſt proficients in ſcripture-knowledge, have the keeneſt ſtomachs to this food of ſouls; and Τροφὴ ψυχῆς ἡ γραφή. the vigorouſeſt piety, by a deſuetude and neg- Athanaſ. lect of it, is ſubject to faint and pine away. Not have we juſt cauſe to repine at an engagement to aſſiduity in the ſcriptures; for there are not near ſo many things, that will require, as there are that will deſerve and recompence a ſerious ſtudy in a book, where both the ſtrict ſenſe and the circumſtances, and expreſſions that cloath it, are richly inſtructive: like that aromatical fruit, of which, not only the kernel is a nutmeg, but the very involving ſkin is mace. This inexhauſted fulneſs occaſioned that panegyrical precept of the Rabbies concerning the law; הפוך בה והפוך כה ארי כולי בה *Pirk avoth. cap. 5.* *Turn it over, and again turn it over, for all is in it:* concurrently to which, the Jew, that tranſlates the Arabian apothegms into Hebrew, thus pronounces; *There proceedeth not a true ſentence out of the mouths of this world's wiſe men, that is not intimated in our law.*

The uſefulneſs of divers texts is ſuch, that we ſhould not only have them in our poſſeſſion, but in a readineſs; and as *David*, diſtreſſed by his mortal enemies, took *Goliah*'s ſword from near the ephod, to wear it whitherſoever he went; ſo Chriſtians, proſecuted by ghoſtly enemies, ſhould be diligent, not only to have an armory well furniſhed with ſpiritual weapons, but to wear this *ſword of the ſpirit* always Epheſ. vi. by their ſides, to ward and thruſt with, upon 17. all occaſions; without needing to depend upon any ſuch thing as concordances, which often cannot be come by, and oftner, not ſoon enough to keep us from being foiled by the father, or the champion of lyes. But now, to engage us to grow ready ſcripturiſts, it is not only true, that as the texts of the bible interchange light with one another, and every new degree of ſcripture-knowledge is not only an acquiſt of ſo much, but an inſtrument to acquire more; ſo is that book a theme ſo comprehenſive and ſo fertile, that the laſt hour of a Chriſtian's longeſt and induſtrioufeſt life will ſtill leave undiſcovered myſteries in it: this, I ſay, is not only true, but it is alſo true, that the doctrines of it are of that importance, and find that oppoſition in our depraved nature, that even thoſe truths, that require but few peruſals to be underſtood, require many to be duly impreſſed; our prepoſterouſly partial memories, being rarely like quickſilver, wherein nothing will ſink but (that pre-

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pretiouſeſt of metals) gold; for that alone is heavier than the mercury. *The word of Chriſt* muſt not be as a paſſenger, or ſparingly entertained in our minds, but muſt dwell there, and that richly: and the word, which St. *James* pronounces *able to ſave our ſouls*, he deſcribes as a graff, which muſt not only be cloſely embraced by that, wherein it is to fructify, but muſt continue there, to bring the ſtock and graff to (if I may ſo ſpeak) concorporate. And indeed we are ſo indiſpoſed to admit, and ſo obnoxious to deface, religious impreſſions, that we need, during our whole life, be converſant with the precepts of leading it piouſly.——But it is ſcarce more faulty in, than incident to, the froward nature of man, to be ever quarrelling with God's method of proſecuting his intentions; and, (as if he were wiſer than his Maker) to criminate his conduct in his diſpenſations. Even that excellent perſon, the glorioufeſt of virgins, and of mothers, whom all ages muſt deſervedly call *Bleſſed*, incurred her divine ſon's reprehenſion, for an intimated offer to alter his purpoſed method in diſcloſing himſelf. But God is too juſt to himſelf, and too merciful to us, to degrade (as it were) his omniſcience ſo far, as to ſuffer himſelf to be ſwayed againſt the dictates of it, by ſuch purblind and perverſe tutors as we; his goodneſs concerns him too much in our inſtruction, to ſuffer him to let our fancies indite his word. To attain his own ends, he makes choice of his own means and inſtruments, without needing our purblind eyes in the election; and what with unfathomable wiſdom he hath been pleaſed to contrive for man's inſtruction with a gracious, though often miſ-underſtood conſtancy, he perſiſts in. He knows, that many, who are diſpoſed to cavil at the preſent contrivance or ſtyle of ſcripture, would be apt to take exceptions at any other: for ſome thing or other it muſt neceſſarily be; and the unimaginable diverſity of humours, judgments and prepoſſeſſions is ſuch, that as theſe now ſay, why thus, and not ſo? others would, in caſe of alteration, be as ready to aſk, why ſo, and not thus? It is queſtionable, whether the Iſraelites were greater murmurers at *Pharoah* in *Egypt*, or at *Moſes* in the deſart: and the children complained of by their companions in the market-place have had either poſterity or predeceſſors in all ages; which have been ſtill of the diſpoſition of thoſe Jews, who imputed the more than prophets rigidneſs of virtue to the great enemy of that lovely quality; and the greater than *Solomon*'s condeſcenſions to the vices he deſigned them to deſtroy. But the great phyſician of mankind is too compaſſionate and wiſe, to let his diſtracted patients preſcribe their own courſe of phyſick, or, to decline our fond and peeviſh cavils, ſhuffle or diſcompoſe thoſe myſterious and profound contrivances; whoſe wiſdom engages the attention, and exacts the wonders of thoſe heavenly unclogged ſpirits, that are ſcarce more advantaged over us by their native abilities, than by the means they have of improving them. And therefore, our Saviour refuſed to deſcend from the croſs, though they, whoſe malice ſerved to fix them there, (the chief prieſts and ſcribes themſelves) declared, that on thoſe terms they would believe on him. And though we are (but too) apt to fancy, that we ſhould be won to our duty, if it were taught or preſſed in ſuch or ſuch a way; yet we may be pleaſed to remember, that it was one in hell, that would needs have another means than the ſcripture, of having ſinners preached to; and one in heaven, that referring them to the ſcripture, declared, *That if men heard not* Moſes *and the prophets, neither would they be perſuaded, though one roſe from the dead, to preach to them.*

Luke i. 48. John ii. 3, 4.

Mat. xi. 16, 17, 18, 19.

1 Pet. i. 12.

Mat. xxvii. 42.

Luke xvi. 31.

IF I addreſt what I write, not to ſo intelligent a perſon as *Theophilus*, but to promiſcuous readers, I ſhould add, to what I have ſaid of the ſeveral exceptions againſt the ſcripture, a cordial advice to all, whoſe parts and leiſure give them not a juſt hope of being able ſolidly to vindicate it either to themſelves or others, to decline as much as they diſcreetly can, the liſtening to objectors or objections, of what ſort, or under what diſguiſe ſoever, againſt that heavenly book; eſpecially, if propoſed by plauſible and inſinuating wits. For it not being neceſſary, (nor indeed poſſible) for every private Chriſtian, to know the opinions and reaſons of all diſſenters about the ſcripture, (no more than for every traveller to be a geographer;) nor requiſite to the knowledge of the way to heaven, to know all thoſe, in which they that miſs it, wander; (as to learn the way from *Dover* to *London*, I need not learn thoſe that lead not thither:) it is not prudent to run a very probable hazard of diſquieting one's faith, and a not improbable one of ſubverting it, only to gratify a needleſs curioſity; an itch, which we are delighted to have ſcattered, but which is exaſperated by being ſo. And frequently, though your deſign ſeem innocent, (as only to hear without believing, and pleaſe your ſelf with ſomething of wit and novelty;) yet thoſe converſations rarely enough prove harmleſs; and (as too frequent and ſad experiance proclaims) generally either abate a degree of your faith, or qualify ſome ardor of your love, or leſſen your reverence for that matchleſs book, or put ſome ſtrange and diſquieting ſcruples into your thoughts, which it is much eaſier to confute than to ſilence. Wherefore, as in infectious times, when the plague reigns, phyſicians uſe more ſtrictly to forbid the ſmaller exceſſes and inordinancies of diet, and the uſe of meats of ill digeſtion, or apt to breed any diſtemper; becauſe every petty fever becomes, through the malignity of the air, apt to turn into the plague: ſo now, that anti-ſcripturiſm grows ſo rife, and ſpreads ſo faſt, I hope it will not appear unſeaſonable to adviſe thoſe, that tender the ſafety and ſerenity of their faith, to be more than ordinarily ſhy of being too venturous of any books, or company, that may derogate from their veneration of the ſcripture; becauſe by the predominant and contagious profaneneſs of the times, the leaſt injurious opinions harboured of it, are prone to degenerate into irreligion. But I fear, you'll think I preach.

The

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The eighth and laſt OBJECTION.

AND now, *Theophilus*, I am arrived at that part of this diſcourſe, wherein it will be fit to examine the grand objection againſt the ſtyle of the ſcripture, which, though a philoſopher would not look upon it as the moſt conſiderable, is yet moſt urged by many of its witty adverſaries; eſpecially ſuch as are wont to exerciſe and gratify their fancy more than their reaſon: the objection itſelf is this: 'That 'the ſcripture is ſo unadorned with flow-'ers of rhetorick, and ſo deſtitute of eloquence, 'that it is flat, and proves commonly ineffica-'cious upon intelligent readers. Inſomuch 'that divers great wits and great perſons, eſ-'pecially ſtateſmen, do either deſpiſe it, or 'neglect to ſtudy it.' And truly, the ſtory is famous of that cardinal, (who flouriſhed in the laſt age) that ſaid, that once indeed he had read the bible, but if he were to do ſo again, it would loſe him all his Latinity. And amongſt thoſe great orators, (as they thought themſelves) who lived in the ſame age and country that he did, the complaint was ordinary, that the reading of the bible untaught them to the purity of the Roman language, and corrupted their Ciceronian ſtyle. And I remember no obſcure prince, (though he ſhall here be nameleſs, becauſe for other qualities I honour him) in no obſcure company, diſputed with me one day an opinion about the ſtyle of the ſcripture, to which the cardinal's ſcorn was a compliment. I wiſh theſe ſaucy expreſſions were but outlandiſh, and could not croſs thoſe ſeas, that environ *England*; (which is not ſo happily ſever'd from the world's vices, as from its continent,) this profane judging ſo boldly that book, men ſhall be judged by, being, if not a native, yet at leaſt a free denizon of *England*. For not only it was one, that I am ſorry I can call our countryman, who is recorded to have ſolemnly preferred one of the odes of *Pindarus*, before all the pſalms of *David*; but I could eaſily add divers reſembbling inſtances, that I have my ſelf been trouled to meet with, were it not that I ſomewhat doubt, whether this kind of profane ſayings be not as well fitter as worthier to be forgotten than remembered, and to be ſuppreſſed than divulged: for (not to mention, that the recording of ſuch enormities puts an ill compliment upon mankind) the ſatisfaction ſome men's curioſities receive by ſuch relations, will ſcarce account for the temptation it gives others to imitate what they find ſome have dared. For there are ſome ſins, whoſe grand determent is a kind of perſuaſion, that they are too horrid to have been committed; and ſome wiſe legiſlators thought it better againſt certain crimes, to uſe the ſilence of the laws, than their threats. I ſhall therefore, without any further mention of ſcandalous particularities, take it for granted, that there have been, and are but too many witty diſreſpecters of the ſcripture. But as for the accuſation it ſelf, which they are alledged to countenance, many defences might be here made againſt it, if divers conſiderations pertinent to that purpoſe, among others, did not belong to ſome of thoſe enſuing parts of my diſcourſe, wherein it is not the ſtyle of the ſcripture, but other themes, that are principally and directly treated of. Yet that you may be aſſiſted to refer hither ſuch parts of the following diſcourſe, as are applicable to the matter under conſideration, I ſhall here take notice to you, that my anſwers to the objection above propoſed may for the moſt part be reduced to theſe five heads of argument.

FIRST, That as to divers parts of the ſcripture, it was not requiſite, that they ſhould be adorned with rhetorical embeliſhments.

NEXT, That the bible ſeems to have much leſs eloquence than indeed it has, to thoſe that read it only in tranſlations, eſpecially the vulgar Latin verſion.

THIRDLY, That by reaſon of the differing notions ſeveral ſorts of men, eſpecially of diſtant nations and climates, have of eloquence; many paſſages, that are thought uneloquent by us, may appear excellently expreſſed to another part of mankind.

FOURTHLY, That there are in the ſcripture a multitude of thoſe texts, wherein the author thought fit to employ the ornaments of language, conſpicuouſly adorned with ſuch as agree even with our notions of eloquence.

AND laſtly, That it is very far from being conſonant to experience, that the ſtyle of the ſcripture does make it unoperative upon the generality of its readers, if they be not faultily indiſpoſed to receive impreſſions from it.

As to the firſt of theſe, having already above declared, that there are many parts of ſcripture, wherein it would have been improper to affect eloquence; I am willing to ſuppoſe, that you have not yet forgot what has been formerly ſaid; and therefore, I am unwilling to detain you on this firſt conſideration. Yet I cannot but on this occaſion take notice to you, that we allow all ſorts of people expreſſions proper and fitted to their ſeveral profeſſions and themes. How many of us can dwell on lawyers, phyſicians, and chymiſts books; though oftentimes written in terms as harſh and as uncourtly, as if thoſe rudeneſſes were their deſign? And yet we can neglect and ſcorn the ſcripture, becauſe in ſome paſſages we there find the myſteries, and other matters of religion, delivered in a proper and theological ſtyle. I remember *Machiavel*, in the dedication of his famous *Prince*, after he had (not cauſeleſly) acknowledged to *Lorenzo de Medici*, (to whom this book is addreſſed) that he had not ſtuffed it with lofty language, or big words, nor adorned it with any of thoſe inveigling outward ornaments, uſual to other authors in their writings; gives this account of the plainneſs of his ſtyle, [*Perche io ho voluto, o chè veruna coſa la honori* (la mia opera) *o che ſolamente la verità della materia, & la gravità del ſoggetto la faccia grata*] that *he thought fit, either that nothing at all ſhould recommend his work, or that only the truth of the diſcourſe and the dignity of the ſubject ſhould make it acceptable*, and exact its welcome. If a mere ſtateſman,

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man, writing to a prince, upon a mere civil theme, could reaſonably talk thus; with how much more reaſon may God expect a welcoming entertainment for the leaſt adorned parts of a book, of which the truth is a direct emanation from the eſſential and ſupreme Truth, and of which the contents concern no leſs than man's eternal happineſs or miſery? And if our nice Italian criticks themſelves cannot, by the plainneſs of *Machiavel*'s ſtyle, nor the forbidding of his writings by the inquiſition, be deterred from as aſſiduous as prohibited a ſtudy of his books; what excuſe will they one day have, that now make the unaffected ſtyle of ſcripture the ſole excuſe of their deſpiſing, (or at leaſt neglecting) that divine book?

The ſecond anſwer to the eighth objection.

SECONDLY, As to the diſadvantage the ſcripture receives by its not being read by thoſe I now reaſon with, in its originals; though I have ſaid ſomething to it already, yet I muſt now reſume it into conſideration, and repreſent, that it is no wonder they reverence not the bible's ſtyle, as they ought, whilſt they judge of that of an Hebrew book by their vulgar tranſlation; which (though ſometimes cauſeleſly enough cenſured by divers proteſtant divines, that would find it no eaſy taſk to make a better, yet) certainly is in many places ſtrangely harſh and barbarous; and by a partial and unlucky affectation of literality, miſſeth the propriety both of the Hebrew ſpeech, and of the Latin. And to adhere to the original words commonly injures its eloquence, and oftentimes ſenſe; rendering excellent expreſſions in ſuch ungraceful ones, as would probably fright readers from it, if it could not very well ſpare fine language. So that to our preſent theme we may not ill apply that notable ſaying of *Mirandula*; *Hebræi bibunt fontes, Græci rivos, Latini paludes.* The old French rhiming tranſlation of *Virgil* makes not the Æneids much more eloquent than *Hopkins* and *Sternhold* have made the pſalms: which ſure being written by a perſon, who (ſetting aſide his inſpiration) was both a traveller, a courtier, and a poet, muſt at leaſt be allowed to contain poliſhed and faſhionable expreſſions in their own language, how coarſely ſoever they have been miſ-rendered in ours. What opinion the eaſtern world hath of the ſweet-ſinger of *Iſrael*, may appear, both by other hyperbolical fictions they believe of him, (whom, with *Moſes*, *Jeſus* and *Mahomet*, they reckon amongſt the four great prophets) and by what *Keſſæus*, (the famed Mahometan writer of the lives of the fathers) relates concerning him; *That when* David *ſang the praiſes of God, the hills, and birds, and beaſts therein accompanied him.* Which groſs literal interpretation of figurative expreſſions in the pſalms, and of his pathetical invitations to the inanimate creatures to join with him in celebrating their common Creator, he ſeems to have borrowed from the Alcoran it ſelf; where *Mahomet* brings God in ſaying, 'We reduced 'the mountains to comply with him, who 'ſhould join with him in praiſes morning and 'evening; the birds alſo flock to him; and 'theſe are obſequious to him.' And though the new teſtament be not written in Hebrew, yet its writers being Hebrews have chiefly conformed themſelves to the ſtyle of the tranſlators of the old teſtament, (which whether or no it conſtitute what criticks of late ſo diſpute of under the name of *Lingua*, or *Dialectus Helleniſtica*, I pretend not to define) and that of the apocryphal authors and other Jews writing in the ſame language; who (except perhaps *Joſephus* and *Philo*) wrote rather, if I may ſo ſpeak, an Hebrew than an Attick Greek; or at leaſt, in a dialect, which (by reaſon of their frequent references to the ſeptuagint's verſion,) abounds, if not with Hebraiſms, with expreſſions obvious in Hebrew writings, and unfrequent in Greek ones, and ſo reliſhes much of the Hebraick ſtyle: of which, as well in the new as the old teſtament, thoſe we reaſon with, being ſtrangers to that primitive tongue, muſt be incompetent judges; there being in the idiotiſms of all languages peculiar graces, which (like thoſe moſt ſubtil ſpirits, which exhale in pouring eſſences out of one veſſel into another) are loſt in moſt (eſpecially if literal) tranſlations; and the holy tongue being that, which God himſelf made choice of to dignify with his expreſſions, having divers whoſe penetrancy is as little transfuſible into any other as the ſun's dazling brightneſs, or the water of a diamond can be undetractingly painted; and having divers words and phraſes, whoſe pithineſs and copiouſneſs none in derived (or other) languages can match. Some of the Hebrew conjugations, as thoſe called *Hiphil* and *Hitpaël*, give ſignifications to verbs, which the want of anſwerable conjugations in weſtern languages makes us unable to fill or equal without paraphraſes, which are very rarely ſo comprehenſive as the original words. And (to hint this upon the by) the ignorance, or not conſidering of this one grammatical truth, hath kept men from fully underſtanding divers paſſages of the new teſtament, wherein the Greek tongue's want of thoſe conjugations hath made active, or intranſitive verbs, be uſed in a tranſitive or reciprocal ſignification. How impertinently men's ignorance of its originals may make them cenſure the ſcripture, I had once occaſion to take notice of, by finding a famous commentator accuſing St. *Paul* of impropriety of ſpeech, in the beginning of that, which is commonly thought to be his firſt epiſtle to the Theſſalonians, but by the learned *Grotius* (in his paradoxes *De Antichriſto*,) not improbably eſteemed to be his ſecond: for whereas inſtead of the Greek words ἀφ' ὑμῶν ἐξήχηται ὁ λόγος τοῦ κυρίου, which ours have rightly Engliſhed, *from you ſounded out the word*; he found in his tranſlation, *a vobis diffamatus eſt ſermo*; not knowing *Paul* to have written in Greek, he would needs correct him, for having written *Diffamatus eſt* inſtead of *Divulgatus eſt.*

Keſſæus, *pag.* 99. *See* Pſal. cxiv. 4. Pſal. xix.

Surat. 3. Vide H. Hotting. 62. *and* 63.

2 Theſ. i. 8.

THIRDLY, we may yet further conſider, that as to many paſſages of ſcripture, accuſed of not appearing eloquent to *European* judges, it might be juſtly repreſented, that the eaſtern eloquence differs widely from the weſtern. In thoſe purer climates, where learning, that is here but a denizon, was a native, the moſt

The third anſwer.

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cheriſhed and admired compoſures of their wits, if judged by weſtern rules of oratory, will be judged deſtitute of it. Their dark and involved ſentences; their figurative and parabolical diſcourſes; their abrupt and maimed way of expreſſing themſelves, which often leaves much place to gueſſes at the ſenſe; and their neglect of connecting tranſitions, which often leaves us at a loſs for the method and coherency of what they write; are qualities, that our rhetoricians do not more generally diſlike, than their practice; yet being perhaps little leſs diſparity in our opinions than in our ways of writing; for their pens, (as if it were a preſage of the different changes the Jews and Greeks have made in point of religion) move from the right hand towards the left; ours (therein imitated by thoſe of the Ethiopians) from the left towards the right; ſo that we think they write backwards, and they, that we do. Of this difference of the notions, that the eaſtern and weſtern colonies of the ſons of *Adam* have harboured concerning eloquence, I ſhall need to mention but one inſtance, that one is ſo remarkable; and that is the Alkoran. How much the Mahometan world boaſts the eloquence of that book, can ſcarce be unknown to thoſe, that have (though but a little) buſied their curioſity in that ſort of inquiries. The ableſt Arabian expoſitors, and other authors, tell us, that all the wit and art of men and dæmons would be unable to hinder that book from being matchleſs. *Mahomet* himſelf was ſo proud of it, that in ſome paſſages in it he defies its oppoſers to equal one ſurat or ſection of it, and ſeems to make its peerleſſneſs an argument of its not being barely of human authority. And the Saracens, depreſſed with their religion's being deſtitute of atteſting miracles, will not ſcruple to reply, that though there were no other * miracle to manifeſt the excellency of their religion above that taught by the prophets, yet the Alkoran it ſelf were ſufficient, as being a laſting miracle that tranſcends all other miracles. How charming its eloquence may be in its original, I confeſs my ſelf too unſkilful in the Arabick tongue, to be a competent judge; my other ſtudies and diſtractions having made me forget moſt of the little knowledge I had once acquired of that flouriſhing language. But though the Alkoran have ſtolen too much from the bible, not to contain divers excellent things, (which is one inducement to me to cite it the oftener;) yet certainly, not only the ancient Latin verſion of it, made by order of the abbot *Petrus Cluniacenſis*, and publiſhed in the laſt age, by the procurement of *Bibliander*, (and of which this is the grand critick *Scaliger*'s exclamation, *Deum immortalem, quam inepta eſt vulgaris illa, quam habemus, interpretatio!*) would ſcarce by our European orators be thought ſo much as of kin to eloquent: but the recent tranſlations I have ſeen of it in French, and (as to divers of it, in) Latin, elaborated by great ſcholars, and accurate Arabicians, by making it very conformable to its eaſtern original, have not ſo rendered it, but that perſons, that judge of rhetorick by the rules of it current in theſe weſtern parts of the world, would, inſtead of extolling it for the ſuperlative, not allow it the poſitive degree of eloquence; would think the ſtyle as deſtitute of graces, as the theology of truth; and would poſſibly as much admire the Saracen admiration, as they do the book. And not only what I have ſeen of the eminent Eaſt-Indians, is ſtrangely incongruous to our notions of eloquence; but what I have peruſed of the famous *Literati* (as they call the learned men) of *China*, though written with great care by the authors, and (as it ſeems) tranſlated with no leſs by the knowing interpreters, would, to an ordinary European orator, appear rather ridiculous than eloquent. But to content ourſelves with the examples we formerly ſelected out of the leſs remote parts of the Eaſt; ſince *Mahomet*, whoſe eloquence (almoſt as proſperous as his ſword) was able to bring credit and proſelytes even to ſuch a religion as his; ſince *Moſes*, that ſo celebrated legiſlator, bred up in the refining court, and all the famed wiſdom of the Egyptians; ſince *Solomon*, who had ſuch incommunicable advantages to improve himſelf, and whoſe wiſdom (eſteemed capable to have governed more kingdoms than his had ſubjects) the weſtern world hath for ſo many ages admired, and the eaſtern only not idolized; and ſince the prophet *Daniel*, whoſe promiſing youth was not only cultivated by the inſtructions of the Chaldean ſages, but enjoyed the diviner tutorage of God's ſpirit, and whoſe matchleſs abilities preferred him, from a captive, to be the chief as well of the Chaldean wiſe men, as the Median princes: ſince theſe applauded writers, I ſay, whom the eaſtern nations ſo much and ſo juſtly admired, by many of our Latiniſts are not thought good writers, becauſe of our differing notions of eloquence; nay, if amongſt Europeans themſelves, *Cicero* hath found many cenſurers, and a book hath been publiſhed to prove, that *Tully* was not eloquent; may not we rationally enough ſuppoſe, that the Grecian and Roman ſtyle, amongſt the eaſtern writers, may not be much better reliſhed than theirs is amongſt us; and that conſequently, in thoſe parts of the ſcripture, whoſe eloquence is not obvious to us Europeans, the pretended want of eloquence may be but a differing and eaſtern kind of it? Specially, if we conſider, that the ancienteſt writers in proſe, now extant amongſt us, were ſcarce contemporary to the lateſt writers of the old teſtament; and yet that eloquence, the dreſs of our thoughts, like the dreſs of our bodies, differs not only in ſeveral regions, but in ſeveral ages. And oftentimes in that, as in attire, what was lately faſhionable, is now ridiculous; and what now makes a man look like a courtier, may within theſe few luſtres make him look like an antick: though how purely it is the mode, that makes ſuch things appear handſome or deformed, may be readily collected from the viciſſitudes obſervable in modes;

Beidavi, Ahmedibn, Edris, *and others.*

Surat. x. *S.* 11. *and S.* 17.

J. Scaliger Epiſt. 362. apud Theod. Hackſpan in libro cui titulus, Fides & Leges Mohamedis. *pag.* 2.

1

* —— *Etſi nihil præter ſolum Alkoranum (adduxiſſet) ſatis hoc foret ad eximiam excellentiam ſupra reliqua, quæ prophetæ adduxerunt: nam ille miraculum eſt, quod in ſecula durat præ omnibus aliis miraculis.* H. Hotting. Hiſt. Orient. *paginas circiter* 300.

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modes; men by intervals relapſing into obſolete faſhions. That there are great changes in that mode of writing men commonly miſtake for eloquence, I ſhall produce no leſs illuſtrious a witneſs than *Seneca*, who in his hundred and fourteenth epiſtle, (to omit other paſſages in his works) not only proves it at large, but ſhows, that in ſome ages, even the faulty ways of expreſſion, conſpired in by the wits of thoſe times, have paſſed for eloquence. The ſcripture ſtyle then, though it were not eloquent now, may have excellently ſuited the genius of thoſe times its ſeveral books were written in; and have been very proper for thoſe people it was primarily deſigned to work upon. And if I would preſume to be paradoxical in a thing I ſo little pretend ſkill in, as eloquence, I might further repreſent on this occaſion, that rhetorick being but an organical or inſtrumental art, in order chiefly to perſuaſion, or delight, its rules ought to be eſtimated by their tendency, and commenſurateneſs to its rules; and conſequently, are to be conformed to by a wiſe-man, but ſo far forth as he judgeth them ſeaſonable and proper to pleaſe or to perſuade: which when he ſees, he can do better by declining them, than by practiſing them, (as orators, like hunters, muſt oftentimes leave the moſt beaten paths, if they will not loſe their game,) he ſhould not ſcruple to prefer the end to the means; the ſcope of the artiſt, to what the ſchools are pleaſed to call the ſcope of the art; and to think it more eligible to ſpeak powerfully, than to ſpeak regularly. And we may hence conſider, that it may be ſomewhat inconſiderate to judge of all eloquence, by the rules of it, that *Cicero*'s admirers impoſe on us; and confound their ſyſtems of precepts with the art of rhetorick, as if they were equivalent, or of the ſame extent. For *Cicero* being reputed (and that deſervedly) an eloquent man, and very ſucceſsful in perſuading his thus and thus qualified hearers; divers, whoſe modeſty and deſpair kept them from aſpiring to more than imitation, obſerving, that *Tully* often made uſe of ſuch and ſuch a contrivance, and ſuch and ſuch figurative forms of ſpeaking, took the pains to reduce thoſe obſervations into rules, which being highly applauded by their ſucceſſors, and by them recruited with ſome reſembling rules drawn from the practice of a few other orators, were afterwards compiled into an art, which as I deny not to be a great help to the imitation of *Tully* and *Demoſthenes*, or thoſe others, from whoſe ſtructure and faſhions of ſpeech ſuch inſtitutions have been drawn, ſo I ſhall no more take it for a complete ſyſtem of rhetorick, than any inſtructions deducible from the journals of *Solomon*'s Tarſhiſh fleets, and from the Grecian and Roman ſea-voyages, for the true and entire art of navigation. For if other perſons, either by an endowment or improvement of nature, can find others equally, or more happy and powerful, or moving, (though never ſo differing) ways of expreſſing themſelves, they ought as little to be confined by the preſcriptions acquieſced in before them, as *Columbus* thought himſelf obliged to be by the rules or practice of ancient navigators; whoſe methods and voyages had he not boldly ventured to vary from, and paſs beyond, how vaſt and rich a portion of the world had his conformity left undiſcovered! And on this occaſion, *Theophilus*, I muſt mention one thing, that I have obſerved, which perhaps you will not think either deſpicable or impertinent; and it is, that though the people of *China* be eſteemed the moſt numerous, the moſt flouriſhing, and (very few, if any, excepted) the moſt civilized nation in the world; though amongſt them the greateſt part of preferments be attainable by verbal learning; and though they have books in their language (how well written, I know not, having never read any of them) of almoſt all kind of liberal arts and ſciences; yet I find by the late traveller in *China*, that writ the Italian hiſtory of that kingdom, and by other authors, that mention their literature, that this populous and ingenious nation, that has been ſo long ſettled in a flouriſhing condition, and more than any other people allows encouragements and recompences to learned men, has not cared to receive rhetorick into the number of their arts and ſciences; preſuming, as one may gueſs, that the confining men's expreſſions to eſtabliſh rules would not be ſo like to enable thoſe to expreſs themſelves eloquently, that nature has indiſpoſed to do ſo, as to hinder others from expreſſing themſelves as well, as, were they left to their full liberty, they would do. I will not ſay, nevertheleſs, that our ſtrict Ciceronian rules are crutches, that may be helps to weak or lame fancies, but are clogs or burdens to ſound and active ones; but this I obſerve, that theſe Utopian laws of oratory are ſeldom rigorouſly impoſed by any, that publiſh other books, that may be examined by them; and that wiſemen, as well in the Weſt, as in the Eaſt, will not eaſily loſe good thoughts, or good expreſſions, becauſe they are not reducible to them. And this I the rather preſs, becauſe I have found but too many ſo blindly ſervile, as to imitate without diſcretion or reſerve in applauded authors, as well the bad as the good; create ſuch artiſts errors rules of art; and make one man's particular fancies, or perhaps failings, confining laws to others; and convey them as ſuch to their ſucceeders, who are afterwards bold to miſ-name all unobſequiouſneſs to their incogitancy, preſumption: as *Seneca* * tells us of divers imperfections of ſtyle, which being familiar to ſome one, who at that time hath the vogue for eloquence, are upon his ſcore copied by his imitators, and by them taught to others: as, (ſays he) when *Salluſt* flouriſhed, his ſtyle made maimed and abrupt ſentences, words ſurpriſingly miſ-placed, and an obſcure brevity paſs for ornaments.

A ſhort digreſſion concerning the art of rhetorick.

And

* — *Hæc vitia unus aliquis inducit, ſub quo tunc eloquentia eſt; cæteri imitantur, & alter alteri tradunt. Sic* Salluſtio *vigente, amputatæ ſententiæ & verba ante exſpectatum cadentia, & obſcura brevitas, fuere pro cultu.* Seneca epiſt. 14.

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And indeed, it is not uneaſy for any man to obſerve the very weeds of cried up rhetoricians cried up for flowers of rhetorick. But having already wandered, perhaps, too far in this digreſſion, I ſhall now conclude it; and though, ſince, it is for the ſcripture, and with its enemies that I am contending, I ſhall venture to do it, with minding our cardinal, and thoſe that ſo undervalue the ſcripture's ways of expreſſion, in compariſon of *Tully*'s, becauſe his books do ſo regularly expreſs the rules of eloquence; that it is no marvel they ſhould find *Cicero*'s writings to be ſo conformable to their laws of art, whilſt they frame thoſe laws of art out of his writings.

BUT, *Theophilus*, I fear I have detained you too long in a digreſſion, whereinto I ſlipt but occaſionally, which is not ſo neceſſary to my preſent argument, but that I am content you ſhould look upon the paradox as any thing rather than an opinion or reaſoning, whereon I lay any great ſtreſs.

The fourth anſwer to the eighth objection.

IN the fourth place then let me repreſent to you, that there are very few, if any books in the world, that are no more voluminous, in which there is greater plenty of figurative expreſſions, than in the bible. Though this may ſeem ſtrange, it is no more than may be made good by more than ſome hundreds of inſtances; there being few tropes or figures in rhetorick, of which numerous examples are not collectible out of the expreſſions of holy writ. I inſiſt not upon this, becauſe a bare catalogue of the rhetorical paſſages, I could enumerate, would too much ſwell an eſſay; and I am informed, that taſk hath been already proſperouſly undertaken by abler pens. Wherefore I ſhall now only ſay, that the eloquence of the ſcripture hath been highly celebrated by no ſmall number of perſons, highly celebrated for eloquence; and that many, who thought themſelves as intelligent in oratory, as thoſe that cenſure the ſcripture, have ſuſpected their own eloquence of inſufficiency worthily to extol that of the prophet *Eſay*; and ſome of them, (amongſt whom I cannot but name that excellent prince of *Mirandula*, whom even the greateſt rabbi of this age ſtyles the phœnix of his age) who after having unſatisfiedly travelled thorough all ſorts of human volumes, have reſted and acquieſced only in theſe divine ones: which will not a little recommend the ſcripture, ſince we may apply to books what an excellent poet ſays of miſtreſſes;

Menaſſe Ben-Iſrael.

Mr. *Waller.*

'Tis not that which firſt we love,
But what dying we approve,

That we expreſs the higheſt value of. And indeed, the beſt artiſts making two parts of oratory; the one, which conſiſts in the embeliſhments of our conceptions, and the other, that conſiſts in the congruity of them to our deſign and method, and the ſuitable accommodation of them to the various circumſtances conſiderable in the matter, the ſpeaker, and the hearers; this latter is peculiarly and inimitably practiſed in the ſcripture; and as much of the former (which is not only leſs conſiderable, but is changeable and unagreed of,) as we have newly ſeen, is made uſe of, as is requiſite to the author's purpoſes, and to manifeſt, that delicacy or ſmoothneſs never ceaſes to be the property of his ſtyle, but becauſe in ſome caſes it would be incongruous to his deſign. And where theſe verbal ornaments are ſpared, they are not miſſed; for as there are ſome bodies ſo well ſhaped and faſhioned, that any clothes become them much better than the moſt fine and graceful would do ordinary (much more crooked or miſ-ſhapen) perſons; ſo there are writings, whoſe matter and ſtructure are ſuch, that the plaineſt language can ſcarce miſ-become them ſo, as to hinder them from eclipſing a trifling or ill-matched ſubject with the ſpruceſt and gaudieſt expreſſions, that can be laviſhed on it. But the truth is, that this florid eloquence is great in many texts, where it is not at all conſpicuous, being hidden in the matter; (as in roſes of diamonds, the jewels oftentimes keep us from minding the flower and the enamel;) and appears not great, but becauſe it is not the greateſt. Some famous writers have challenged *Demoſthenes* and *Cicero* to compare with the prophet *Eſay*; in whom they have not only admired that lofty ſtrain, which artiſts have termed the ſublime character, but even that harmonious diſpoſition and ſound of words, (I mean in their original) which the French prettily call, *la cadence des periodes*.

WHEREFORE, *Theophilus*, whereas I have formerly acknowledged, that there are ſome witty men, that ſpeak very diſreſpectfully of the ſcripture, I hope, that if you meet with any ſuch, you will conſider, that it has among the wits as well celebrators, and admirers, as diſregarders. And that you may think this deſire of mine the more reaſonable, be pleaſed to conſider with me, that there are divers things, which ought to leſſen the authority of the diſparagers of the ſcripture, in the caſe under conſideration.

FOR firſt, how few of them, think you, are wont to read it in its originals; and how much a leſs number is there of thoſe, who both know and duly conſider all thoſe particulars repreſented in the paſt diſcourſe on the behalf of the ſcripture ſtyle? So that in a great many men of parts, their undervaluation of the ſcripture proceeds not from their having great wits, but from their not having a competent information of what can be alledged for its juſtification.

BUT though we ſhould ſuppoſe thoſe we ſpeak of not to want information, yet we may well ſuppoſe many of them not to be free from vanity and envy; there ſcarce being any fault ſo incident to great wits, as the ambition of being thought ſtill more and more ſo, and the unwillingneſs, that any compoſures but their own, or thoſe they have a hand in, ſhould be celebrated; as if all praiſes were injurious to them, that are given to any other. It need be no great wonder then, if ſo excellent a book as the ſcripture have, as well enviers, as admirers; and if there be divers, who cavil

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cavil at it, and ſeem to undervalue it, out of a criminal fondneſs of the over-ambitioned title of a wit, which they hope to acquire by unherding and keeping out of the road, and owning their being able to ſlight and diſgrace that, which ſo many others reverence and venerate.

BUT thirdly, it is ſufficiently notorious, that of the oppoſers of the ſcripture there is a great part, whoſe vanity and envy, though no ſmall faults, are not their greateſt crimes; but who live ſo diſſolutely and ſcandalouſly, that the ſuſpicion cannot but be obvious, that ſuch decry the ſcripture for fear of being obliged (at leaſt for meer ſhame) to live more conformably to it. And that it were no ſlander to affirm it to be their intereſt, not their reaſon, that makes them find fault with a book, that finds ſo much fault with them; and they who are ſenſible of the truth of that of our Saviour, where he ſays, *That many love darkneſs rather than light, becauſe their deeds are evil*; and that *he that doth evil, hateth the light, neither cometh to light, leſt his deeds ſhould be reproved*; will not be much moved to find conſcious malefactors find fault with the ſtatute-book, but will rather look upon theſe ſinners cenſures of the ſcripture, as apologies they judge neceſſary to palliate their ſins, or as acts of revenge, for their being expoſed in all their deformity to the eyes of the world, and of their own conſciences, in the bible; and conſequently will be inclined to think, that their irreligious expreſſions do rather ſhew what they would have men believe of them, than what they believe of the ſcripture, by ſeeming to ſlight which, they hope to have their vices imputed rather to a ſuperiority of their reaſon over that of others, than a ſervitude of their reaſon to their paſſions.

John iii. 19, 2c.

A long digreſſion againſt prophaneneſs, as it relates to the ſcripture. Pſ. xxxix. 3.

[HERE I thought to paſs on to another argument, but (to expreſs my ſelf in *David*'s words) *While I was muſing, the fire burned*, and my zeal for the ſcripture, together with the charity it has taught me to exerciſe even towards its oppoſers, ſuffers me not, with either ſilence or languid reſentments, to ſee how much that incomparable book loſes of the opinion of leſs diſcerning men, upon the account of their diſreſpects, who are (whether deſervedly or not) looked upon as wits. And therefore to what I have repreſented to invalidate the authority of theſe few perſons, otherwiſe truly witty, that undervalue the ſcripture, I am obliged to add, that beſides them, there is a number of thoſe, that ſlight the ſcripture, who are but looked upon as wits, without being ſuch indeed; nay, who, many of them, would not be ſo much as miſtaken for ſuch, but for the boldneſs they take to own ſlighting of the ſcripture, and to abuſe the words of it to irreligious ſenſes, and perhaps paſſing from the impudence of perverting inſpired expreſſions, to deliver obſcene thoughts. But to knowing and ſerious men, this prevaricating with the ſcripture will neither diſcredit it, nor much recommend the prophane prevaricator: for a book's being capable of being ſo miſ-uſed is too unavoidable to be a diſparagement to it. Nor will any intelligent reader undervalue the charming poems of *Virgil* or of *Ovid*, becauſe, by ſhuffling and diſguiſing the expreſſions, ſome French writers have of late been pleaſed out of rare pieces to compoſe whole books of what they call, *Vers Burleſques*, deſigned by their ridiculouſneſs to make their readers ſport: and on the other ſide, to abuſe diſmembred words and paſſages of any author to meanings he never dreamed of, is a thing ſo eaſy, that almoſt any man may have the wit to talk at that prophane rate, that will but allow himſelf the ſaucineſs to do ſo. And indeed experience ſhews, that if this vice itſelf do not make its practices ſuſpected of the being neceſſitous of the quality they put it on to be thought maſters of, yet at leaſt perſons intelligent and pious will not be apt to value any diſcourſe as truly witty, that cannot pleaſe the fancy without offending the conſcience, and will never admire his plenty, that cannot make an entertainment, without furniſhing out the table with unclean meats; and conſidering perſons will ſcarce think it a demonſtration of a man's being a wit, that he will venture to be damned to be thought one. And that which aggravates theſe mens prophaneneſs, and leaves them excuſeleſs in it, is, that there are few of theſe *fools*, (for ſo the wiſe-man calls them) that *make a mock of ſin*; *that have ſaid in their hearts, that there is no God*; or that the ſcripture is not his word; their diſreſpect to the ſcripture ſpringing from their vanity, not their incredulity. They affect ſingularity, for want of any thing elſe than is ſingular; and finding in themſelves ſtrong deſires of conſpicuouſneſs, with ſmall abilities to attain it, they are reſolved with *Eroſtratus*, that fired *Diana*'s temple, to be talked of for having done ſo, to acquire that conſiderableneſs by their ſacrilege, which they muſt deſpair of from their parts. And indeed there want not many, who have ſo little wit, as to cry up all this ſort of people for great wits. And as withies, whilſt they are ſound, grow unregarded trees, but when they once are rotten, ſhine in the night; ſo many of theſe pretenders, whilſt they were not very prophane, were (and that juſtly) eſteemed very dull; but now that their parts are abſolutely corrupted and perverted, they grow conſpicuous, only becauſe they are grown depraved. And I ſhall make bold to continue the compariſon a little further, and obſerve, that as this rotten wood ſhines but in the night; ſo many of theſe pretenders paſs for wits but amongſt them, that are not truly ſo. For perſons really knowing can eaſily diſtinguiſh betwixt that, which exacts the title of wit from our judgments, and that which but appears ſuch to our corruptions. And how often the diſcourſe we cenſure is of the latter ſort, they need not be informed, that have obſerved, how many will talk very acceptably in derogation of religion, whom, upon other ſubjects, their partialleſt friends acknowledge very dull; and who are taken notice of for perſons that ſeldom ſay any thing well, but what it is ill to ſay. And queſtionleſs, there is no ſmall

Pſ. xiv. 1.

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number of theſe ſcorners, whoſe cenſures of the ſcripture's ſtyle are little leſs guilty of preſumption than profaneneſs. I have of late years met with divers ſuch vain pretenders, who bluſh not to talk of rhetorick more magiſterially than *Ariſtotle* or *Tully* would; and ſupercilioufly to deride, in compariſon of their own writings, and theirs who write like them, not the bible only, but the moſt venerated authors of antiquity; and, to uſe *Aſaph*'s words;

Pſ. lxxiii. 8, 9. *They ſpeak loftily, they ſet their mouth againſt the heavens, and their tongue walketh thorough the earth:* they ſpeak arrogantly and cenſoriouſly both of God and men; whilſt themſelves oftentimes underſtand no tongue but their mother's; and are ſtrangers enough to rhetorick, not to know the difference betwixt a trope and a figure, betwixt a proſopopœia and a metaphor, or betwixt a climax and a metonymy. Nor is our wonder like to ceaſe, to find theſe tranſcendent wits, (as they are pleaſed to think themſelves,) ſo undervalue the ſcripture, by conſidering the rare compoſures they deſpiſe it for; theſe being commonly no other than ſome drunken ſong or paltry epigram, ſome fawning love-letter, or ſome ſuch other flaſhy trifle, that doth much more argue a depreſſed ſoul, than an elevated fancy. Some of theſe gallants by their tavern ſongs uſe the muſes like anchovies, only to entice men to drink: another with more ſolemnity and applauſe makes the muſes (what the French call) the confidents of his amours, proſtitutes his wit to evince and celebrate the defeat of his reaſon, and never conſidering how apt ſelf-love makes us to magnify any thing that magnifies us, is proud to have wit aſcribed him by as bribed as incompetent judges of it; and takes it for as high a proof as deſirable a fruit of eloquence, to perſuade a vain miſtreſs, that ſhe is handſome and adored, to whom it were eloquence indeed to be able to perſuade the contrary. Divers of the Jews are wont to mention the names of deceaſed ſinners, with that brand taken out of the *Proverbs*, *May the name of the wicked rot*; but as the filthieſt ſwine after their death are ſalted, and the gammons made of their fleſh are ſerved in, all ſtuck with bays; ſo divers, that have lived notorious Epicures, have too often, after their death, not only their names ſalted (not to ſay embalmed) with flattering epitaphs, and (I wiſh, ſeldomer, as flattering) funeral ſermons; but have their drunken or luſtful rhimes extolled with ſuch elogies by their ſurviving reſemblers, that not only good Chriſtians, but good poets cannot but grieve and bluſh, thus to ſee bays, that ſhould be appropriated to, and crown that heavenly gift called poetry, when mindful of its dignity and extraction, it indears to us by our fancies truths, that ſhould have an influence on our affections, (by cloathing excellent thoughts in ſuitable and winning dreſſes) proſtituted and degraded to make wreaths for thoſe, who have no better title to them, than a few ſenſual rhimes, where the dictates of *Horace* are as little conformed to, as the example of *David*; and the laws of the art little leſs violated than thoſe of religion. It is pleaſant to obſerve, in how many of ſuch copies of verſes, the themes appear to have been made to the conceits, not the conceits for the themes; how often the words are not ſo properly the clothes of the matter, as the matter the ſtuffing of the words; how frequently ſublime nonſenſe paſſes for ſublime wit; and (though, according to my notion of it, that is indeed true wit, which it is more eaſy to underſtand, than it is not to admire it) how commonly confuſed notions, and abortive or unliked conceptions, are in exotick language, or ambiguous expreſſions, expoſed to the uncertain adoption of the courteous reader; which the writers are emboldened to expect favourable, by finding men once thought (whether deſervedly or otherwiſe) lofty wits, to have ſo often the luck of parrots, and of thoſe that talk in their ſleep, who are not ſeldom underſtood by others, when they do not underſtand themſelves. And very much of kin to their verſes is their proſe. For though I am far from denying, that thoſe, that have ſtore of wit, may expreſs ſome of it in an addreſs to a great man, or in writing to a miſtreſs; yet as for ſuch prophane perſons I am now ſpeaking of, who rather would be thought wits, than are ſo, it is eaſy to diſcern, that very many of their almoſt as much flattered as flattering letters of love and compliment are but prologues to, and paraphraſes of the ſubſcription, (your humble ſervant.) Though love be univerſally thought to make the fancy ſoar, (lovers like ceeled pidgeons flying the higher for having been blinded) and though even the wiſer obſerve, that, like war, which is wont as well to raiſe ſoldiers of fortune, as to ruin men of fortune, love warms and elevates leſſer wits, though it too often infatuate the great ones: yet a witty lady did not ſcruple to ſay frequently, that give her but leave to bar half a ſcore words, and ſhe would undertake to ſpoil all the fine letters of our amorous gallants. I applaud not the ſeverity of this lady, and think her challenge reliſhes as much of vanity as ſkill; but yet, to expreſs the ſenſe of theſe few words, [I deſire you ſhould think I can write well, am a civil perſon, and your humble ſervant,] being the drift and ſubſtance of moſt of theſe ceremonial papers; theſe (oftentimes as tedious as ſervile) amplificators, with all their empty multiplicity of fine words, do but, like market-people, pay a piece in twenty ſhillings. In wits not bleſſed with ſolid reaſon and learning, (that is, in moſt readers) fancy being the predominant faculty, makes them reliſh thoſe writings moſt, where fancy unrivalled reigns. And therefore, though I dare not ſay, that it requires no great parts for thoſe to write high and acceptable compliments, that think nothing fit to be endeavoured in compliments, but to make them acceptable by making them high enough; (flattery and prophaneneſs ſeeming in ſuch compoſures what ſpots are in leopards, blemiſhes, that make a great part of their beauty) or for a flatterer to perſuade thoſe vain perſons, that will readily believe a man, even when he doth not believe himſelf: yet ſure it gives much latitude and liberty to a writer, not to be obliged to believe

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believe what he ſays, not ſay but what he thinks either will be or ought to be believed. And truely, they that exerciſe their pens on either ſort of themes (I mean thoſe that require only new or pleaſing fancies, and ſmooth language, and thoſe that require learning and knowledge pertinently and handſomely expreſt) do, I doubt not, find it much leſs difficult for writers to delight, where they propoſe themſelves no higher end, and ſcruple at nothing they judge conducible to that inferior one; than to pleaſe, where to do ſo is but a ſubordinate end, which men allow not themſelves, neither the uſe of all proper means to attain. Nor do I queſtion but ſuch perſons find it far more eaſy to write acceptably on ſubjects, where they are not tied to ſpeak either reaſon or truth; than to write well on a theme, where men are confined to write nothing but what they judge uſeful, and what they can make good, as conſidering that they may be called to account by men for what they publiſh, if not by God, both for their own time and that of their readers. And indeed, when I compare the moſt applauded trifles of theſe undervaluers of the ſcripture ſtyle, with the celebrating diſcourſes of it extant in the learned writings of St. *Auſtin*, St. *Hierom*, *Tertullian*, *Lactantius*, *Chryſoſtom*, *Mirandula*, and others, whoſe penetrant and powerful arguments defeat not God's enemies, as *Samſon* did the Philiſtines, *with a jaw-bone of an aſs*, nor as *Shamgar with an ox-goad*, (I mean with blunt and deſpicable weapons) but as *Elias* did, *with fire from heaven*; and whoſe apologetical defences of the ſpiritual *Jeruſalem* are glittering and ſolid, as the wall of the heavenly *Jeruſalem* is deſcribed to be of jaſper, *and the foundations of the wall garniſhed with all manner of precious ſtones:* when I compare, I ſay, the compoſures of our frothy cenſurers with thoſe of the ſacred orators; methinks I diſcern ſuch a difference betwixt them, as I have obſerved betwixt thoſe juſtly admired ſtatues I have ſeen in the Capitol, and the larger ſort of babies that we find in the exchange. For the former, beſides their vaſtneſs, are ſo recommended by the worth and permanency of their matter, the excellency of their workmanſhip, and the nobleneſs of what they repreſent, that they are moſt prized by the beſt artiſts, and time is not only unable to conſume them, but ſtill increaſes mens value of them; whereas the latter are little trifles, ſcarce welcome to any but children in underſtanding, and admired only for a gaudy effeminate dreſs, which will quickly either be ſullied or worn out; and a faſhionableneſs which within a ſhort while will perhaps be ridiculous. But ſuppoſing at length, that the profane aſpirer ſhould be ſo lucky, or ſo ſucceſsful, (for happy I cannot think it) as to attain the ſo criminally courted notedneſs, yet will he have no great cauſe to boaſt the purchaſe, when he ſeriouſly conſiders, that the devil, who ſeduces other ſinners like men, with current coin or ſparkling jewels, (ſomething that either advantages their intereſts, or delights their ſenſes;) hath enveigled him, like a child, with a whiſtle; a triſle that only pleaſes with a tranſient and empty ſound; and, that fame is a bleſſing only in relation to the qualities, and the perſons that give it, ſince otherwiſe the tormented prince of devils himſelf were as happy as he is miſerable; and famouſneſs unattended with endearing cauſes is a quality ſo undeſirable, that even infamy and folly can confer it; as *Momus* is little leſs talked of than *Homer*; the unjuſt *Pilate* is more famous than *Ariſtides* the juſt; and *Barabbas* his name is ſignally recorded in ſcripture, whereas the penitent thief is left unmentioned. And ſure the higheſt favours, that applauſe can impart, and the being (though never ſo loudly) cried up for a wit, will hardly ſo repair the puniſhment of prophaneneſs, but that its wretched ſufferer will find but ſmall ſatisfaction in having his name celebrated in other books, whilſt it is blotted out of that of life. And as for thoſe (you know who I mean) that aſpiring to poſthume glory, endeavour to acquire it by irreligious writings deſtinated not to ſee the light, till their authors be gone to the region of darkneſs; I cannot but admire to ſee an ambition, that projects beyond the grave, ſtep ſhort of heaven; and cannot but think thoſe wits the greateſt fools, who, to tempt praiſes they ſhall never hear, provide themſelves torments that they ſhall ever feel. For though prophaneneſs, by thoſe that are guilty of it, be too often thought but a ſmall ſin, becauſe they look upon it but as a verbal one; yet I could eaſily repreſent it under another notion, if I would here repeat what I have diſcourſed, touching indulgence to reputedly ſmall and verbal ſin in another paper, from which though I will not now tranſcribe any thing, yet I cannot but wiſh it were well conſidered, how affronting ſpeeches concerning God's word are like to be looked upon in that great day, when (to borrow St. *Jude*'s terms) *the Lord ſhall come with ten thouſands of his ſaints, to execute judgment upon all, and to convince all that are ungodly among them*, (not only) *of all their ungodly deeds, which they have ungodlily committed*, (but) *alſo of all their hard ſpeeches, which ungodly ſinners have ſpoken againſt him.* And indeed theſe preſumed peccadillos, though oftentimes in health and proſperity they appear not to us to blemiſh much our conſciences, yet when in our diſtreſſes, or at the approaches of death, God comes, as the prophet ſpeaks, *to ſearch men's hearts as it were with candles, and puniſh the men that are ſettled upon their lees*, (which whilſt a liquor is, it may look clear, and be taken for defecated, but a little agitation of the veſſel ſtrait makes it troubled and muddy;) they appear in a terrifying form. For as paper written upon with juice of lemons may wear white, (the livery of innocence) whilſt it is kept from the fire; but being held to it, black lines do preſently appear: ſo out of many conſciences, that ſeem clear in proſperity, the fire of adverſity draws out the latent blackneſſes, and makes us read things undiſcerned there before. And queſtionleſs, if, as the ſcripture informs us, *there are ſins, whoſe cry is able to reach heaven*; ſo loud a

Judg. xv. 15.
Judg. iii. 31.
2 Kings i. 10.
Rev. xxi. 10, 18, 19.
Jude ver. 14, 15.
Zeph. i. 12.
Gen. xviii. 21.

crime

crime as the prophaneneſs I am now ſpeaking of, is likely to do more than whiſper there; eſpecially, ſince it is much to be feared, that many of theſe ſcoffers (as they ſeem to be called in the ſcripture) which they bear witneſs to, by cavilling at it, do *rebel againſt the light*, and *kick againſt the pricks* of their own conſciences: ſuch a crime, I ſay, will be ſo far from whiſpering in heaven, that it will rather give an alarm, that will rouſe up provoked juſtice; whoſe inflictions, like ſtones tumbled down from the towers of an aſſaulted place, the longer they are in falling on men, the more fatally they oppreſs them. In which regard perhaps, the feet of our Saviour in the Apocalypſe are deſcribed to be like unto fine braſs, as if they burned or glowed in a furnace; to intimate, that though he be very ſlow in his march to deſtroy the wicked, yet he is as ſure, when once he pleaſes to tread them under foot, to cruſh and conſume them. If there be no injury, that more exaſperates than contempt, nor no contempt, that more provokes than that, which offends directly and immediately, (the affronters thereby proclaiming, that they are neither aſhamed nor afraid of angering) how provoking may we think that crime, which makes God the ſubject of our deriſion; and that with ſo little circuition, as to abuſe that word, which he ſo ſolemnly declared his mind by to mankind? *Plutarch*, to manifeſt how much ſome idolaters did more incenſe the Deity than ſome artiſts, tells us, he ſhould eſteem himſelf leſs injured by the man, that ſhould doubt or deny, that there was ever any ſuch man as *Plutarch*, than by him, that ſhould affirm, that there was ſuch a one indeed, but that he was an old fellow, that uſed, like the poet *Saturn*, to devour his children; and was guilty of thoſe other crimes imputed by the Heathen to their gods. Upon a like account, we may eſteem God leſs provoked by their unbelief, that doubt or reject the ſcripture, than by their prophaneneſs, that make ſo ſacrilegiouſly bold with it; ſince the latter impute to God the inditing of what they endeavour to make men think fit to have ſport made with it. This of prophaneneſs is ſo empty and unprofitable a ſin, that it ſcarce gets the practiſer any thing but an ill name amongſt good men upon earth, and a worſe place amongſt bad men in hell; by making his enmity to piety ſo malicious and ſo diſintereſted, that he will endeavour to do religion harm, though it be to do himſelf no good. He is ſuch a volunteer ſinner, that he hath neither the wit nor the excuſe of declining his conſcience in compliment to his ſenſes; and though he ever makes but an ill bargain, that gets in hell to boot, yet thoſe I would reclaim, come far ſhort of the comparative wiſdom of their folly, who to gain ſo conſiderable (though yet over-purchaſed) a poſſeſſion as the whole world, ſhould part with their own ſouls. And ſure a ſin, that is injurious to God's glory, and is apt to ſubvert (what he and good men prize next,) the dearly purchaſed, immortal, and invaluable ſouls of men, and to *deſtroy them for whom Chriſt died*; will not by being verbal, be protected from being heinous. And to thoſe that practiſe it, I ſhall recommend the latter half of the epiſtle of *Jude*; which, though it ſeem properly to relate to the Gnoſticks, or Carpocratians of his time, will deſerve a trembling attention from thoſe that revive the ſins there condemned, in ours; and who would do well, by ſeaſonably conſidering the fate there threatned to their predeceſſors, to tremble at their crime. But for fear of loſing it, I ſhall not ſpend more time in endeavouring to diſabuſe our ſcorners; whom I ſhould have left to the quiet enjoyment of their unenvied ſelf-admiration, had not their deſpiſing the ſcripture, upon a preſumption of their own matchleſs wit, (like *Jeroboam*, that forſook that incomparable ſtructure, the temple, where God did ſo glorioufly and peculiarly manifeſt himſelf to men, to worſhip calves of his own making,) engaged me, in conformity to the wiſe man's counſel in ſuch caſes, to *anſwer the fool according to his folly, leſt he be wiſe in his own conceit*. For my reproofs are addreſſed to thoſe called wits, but as they are traducers and undervaluers of the ſcripture, not as they either pretend to, or enjoy, a quality, which I have the juſtice to eſteem, though not the happineſs to poſſeſs; and which my value for it, and my charity for men, makes me troubled to ſee arrogated by many that want it, and by too many, that have proſtituted it to gratify other people's pride, or their own luſts. How * much happier were it for perſons of choice parts to employ them, as *Bezaleel* and *Aholiab* did theirs, in working for the ſanctuary; in aſſerting the embelliſhing divinity? The ſtructure will not alone deſerve the ſkilfulleſt hand, but though it reject not goat's hair, and coloured badger's ſkins, will admit not only purple and fine twined linen, but gold, ſilver and precious ſtones; the richeſt ornaments, that learning and eloquence can grace theology with, being not only merited by that heavenly ſubject, but being applicable to it, as much to their own advantage as to that of their theme. We ſee how ambitious men are, to leave a good name behind them, and appear in the habit of virtue to their own after time: witneſs the artifices and hypocriſy men generally veil or diſguiſe their ſins with; and the flattering epitaphs, with which ſo many vicious perſons endeavour to convey themſelves to the good opinion of poſterity. Now they that write piouſly, as well as handſomely, have the advantage of getting themſelves the reputation as well of virtuous as of able men, and beſides that double recompence may expect a third (tranſcending both) in heaven, where they that (in the true ſcripture-ſenſe) *be wiſe, ſhall ſhine as the brightneſs of the firmament, and they that turn many to righteouſneſs, as the ſtars for ever and ever*. It is the general complaint and grief of perſons truly zealous, that there are many more wits and grandees now-a-days, who, by perverting God's gifts to the ſervice of idols (of pride or pleaſure) of their own ſetting up, reſemble the degenerate Jewiſh church, of whom God complains by *Hoſea*, that *ſhe did not know, that he gave her the corn and wine and oil, and multiplied her ſilver and her gold, which they prepared for*

2 Pet. iii. 3.
Jude ver. 17, 18.
Rev. i. 15.
Rom. xiv. 15.
1 Kings xii. 28, 32
Proverbs xxvi. 5.
Exod. xxxi. 3, 4, 5, &c.
Dan. xii. 4.
Hoſ. ii. 8.

* An appendix to the former diſcourſe, concerning witty men to make amends for the profanenes of another.

for Baal; than that, (by an humble dedication of their choiceſt abilities to God's ſervice,) imi-
1 Chron. xxix. tate holy *David* and his princes; who having conſecrated their gold and ſilver and precious ſtones, towards the enriching and embelliſhing of the temple, perfumed that vaſt offering with this acknowledgment to God; *All things come*
ver. 14. *of thee and thine own have we given thee.* But though now I know divers great perſons and great wits amongſt us, who very unmindful of
1 Cor. iv. 7. that text, *What haſt thou that thou didſt not receive*, like thoſe ungrateful clouds that obſcure the ſun that raiſed them, oppoſe the glory of that God, who elevated them to that height: yet I do not abſolutely deſpair, that as God hath been pleaſed to make uſe of ſeveral royal pens for the tracing of his word, and to make a perſon, learned in all the wiſdom of the Egyptians, his firſt ſecretary; ſo he will one day engage both the grandees and the wits to ſtrive to expiate, by their devotion and ſervice to the ſcripture, the injuries, that irreligious parts and greatneſs have done it. I will not tell you, *Theophilus*, that an early ſtudy of religion would gain to its party moſt of thoſe many wits, that will be ſure to contend for whatever opinion is expreſſed by the wittieſt things they can ſay. But I will tell you, that a particular conſideration, that makes me wiſh to ſee witty writers more generally employ their pens on the behalf of religion, is, that the ſervices they do
Nicholo Machiavelli *nel libro del Principe*, c. 10. it, endear it to them: for as *Machiavel* ſmartly obſerves, and as the love of parents and nurſes to children may evince, *La natura de gli huomini è coſi obligaſi per li beneficii che eſſe fanno, come per quelli che eſſi ricevono.* It is natural to men, to be as well engaged by the kindneſſes they do, as by thoſe they receive. And for the encouragement of the poſſeſſors of great parts, to employ them on religious themes, ſuch as the holy ſcripture; I ſhall repreſent to them, that even that immortality of name, which worldly writers (for the moſt part) ſolely aim at, is not by pious writers leſs found for being laſt ſought: their theme contracts not their fame by a true diminution, but only by compariſon to a greater good: their looking upon their own glory but as an acceſſion to God's, not hindering others from praiſing that wit and eloquence they praiſe God with; as beauty made it ſelf admirers, though in veſtals, and a rare voice may raviſh us with a pſalm; or as the jewels that adorned it, ſhone with their wonted luſtre on *Aaron*'s
1 Tim iv. 8. breaſt-plate; yes, *as godlineſs is profitable unto all things, having promiſe of the life that now is, and of that which is to come; and the hundred fold now in this time*, is very conſiſtent with
Mark x. 30. the *eternal life in the world to come:* ſo is it very poſſible for the ſame pious writer to have his name written, at once in both thoſe immortal books of life and fame; and, (like the inſpired poet, holy *David*) wear as well here a crown of laurel, as hereafter, τὴν ἀμαράντινον τῆς δόξης
1 Pet. v. 4. στέφανον, that unfading crown of glory St. *Peter* ſpeaks of. And though we are too generally now-a-days ſo ſinful, that we ſcarce reliſh any compoſure, that endeavours to reclaim us from being ſo; yet leſs licentious and more diſcerning times, (which may be perhaps, approaching,) will repair the omiſſions and faſtidiouſneſs of the preſent, by an eminent gratitude to the names of thoſe, that have laboured to tranſmit to others, in the handſomeſt dreſs they durſt give them, the truths themſelves moſt valued. And I obſerve, that though *Solomon* himſelf delivered ſo many thouſand ſongs and proverbs, and the nature of beaſts, birds, reptiles, and fiſhes, together with the hiſtory of plants from the *cedar of* Lebanon, *even to the*
1 King. iv. 31, 32, 33. *hyſſop that ſpringeth out of the wall*; yet thoſe three only treatiſes, deſigned peculiarly for the inſtruction of the church, ſurvive their loſt companions. And as anciently the manna, which the Iſraelites gathered to employ in their domeſtic uſes, laſted not unputrified above a day or two; but that, which they laid up in the ſanctuary to perpetuate or ſecure God's glory, continued whole ages uncorrupted: ſo the
Exod. xvi. ver. 20, 33, 34. books written to ſerve our private turns of intereſt or fame are oftentimes ſhort-lived; when thoſe, conſecrated to God's honour, are, for that end's ſake, vouchſafed a laſtingneſs and kept from periſhing. And thoſe many dull and uneloquent gloſſes and expoſitions of the ancient Jews, that the merit of their theme hath preſerved for ſo many ages, may aſſure us, that the ſcripture doth often make their names and writings that illuſtrate it, partakers of its own prerogative of immortality. Not
Pſal. cxix. 99. to mention that, (according to that of the Pſalmiſt, *I have more underſtanding than all my teachers*; *becauſe*, תי, *thy teſtimonies are my meditation*) ſuch an employment of parts doth oftentimes invite God to increaſe them; as he
Mat. xxv. 28. that had moſt talents committed to him, for improving them to his Lord's ſervice, was
John ii. *to the tenth verſe inclusively.* truſted with more of them; and he, who employed ſome few cups of his wine to entertain our Saviour, had whole veſſels of his water turned into better wine. Certainly, tranſcendent wits, when once they addict themſelves to theological compoſures, improve and grace moſt excellently themes ſo capable of being ſo improved. They need ſmall time to ſignalize their pens; for poſſeſſing already in a ſublime degree all the requiſites and appropriates of rare writers, they need but apply that choice knowledge and charming eloquence to divine ſubjects to handle them to admiration; as *Hiram* ſucceſsfully uſed the ſkill he had learned in *Tyre*, in the building and adorning of God's
1 Kings vii. 13, 14, &c. temple; and *Jephtha* victoriouſly employed the military gallantry and art, that had made him conſiderable in the land of *Tob*, in de-
Judg. xi. fending the cauſe, and defeating the enemies of God. Of this truth the primitive times afford us numerous and noble inſtances; but eſpecially that ſtupendous wit St. *Auſtin*, (whom I dare oppoſe to any of the wits, that have dared to oppoſe the ſcripture,) the productions of whoſe wit in his unregenerate ſtate, and after his converſion to the catholick faith and piety, oblige me to reſemble
Num. xvii. 4, 8. him to *Aaron*'s rod; which (ſuppoſing the truth of their opinion, that think it to be the ſame that *Moſes* uſed) whilſt it was employed abroad, did indeed for a while work wonders,

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that made it much admired; but when once it came to be laid up in the tabernacle, unconfined to the uſual laws of other plants, it ſhot forth and afforded permanent fruit in a night. But, *Theophilus*, to recover my ſelf at length from my over-prolix digreſſion, I muſt remember, that it was objected, that as well divers great princes and great ſtateſmen, as many great wits, diſ-eſteem, or at leaſt neglect the ſcripture. And indeed, though I am ſorry it cannot, yet it muſt not be denied, that notwithſtanding all the prerogatives of the bible, there needs not much acquaintance with great men, to ſhew many of them, that though they deny not God to be the author, deny themſelves the bleſſing of being readers of it, ſome out of lazineſs, and others out of pride; both which lurk under the pretext of multiplicity of important avocations. But ſince, your quality, *Theophilus*, and ſtation in the world, may either make you need to be armed againſt this temptation, or give you opportunities to aſſiſt thoſe that are endangered by it, give me leave, on this occaſion, to tell you, that thoſe grandees, that pretend want of leiſure for their neglect of the reading of the ſcripture, muſt be able to give a rare account of all the portions of their time, to make thoſe paſs for a miſ-employment of it, that are laid out towards the purchaſe of a happy eternity; which it is not over-modeſt for thoſe to expect from God, that grudge him the rent of that time, of which they are but his tenants at will. But to manifeſt how unlikely this pretence is to paſs current; I ſhall repreſent, that in the ſelf-ſame chapter, where God faſhions a king fit to govern his own people, he enjoins concerning
Deut. xvii. 18, 19. the book of the law, that *it ſhall be with him, and he ſhall read therein, all the days of his life*;
Ver. 20. which the next verſe intimates ſhall be thereby prolonged. And indeed, it often happens, that as *Samuel*'s barren mother for lending one of her children freely unto the Lord, was bleſt with many others; ſo the days conſecrated to
1 Sam. ii. 20, 21. God's ſervice rather improve than impoveriſh our ſtock of time. Nay, the king was, (in
Ver. 18. that place of *Deuteronomy*) not only obliged to read the law, but to write it too: upon which ſubject, if I miſ-remember not, the learnedeſt
Rambam, *vr*, Rabbi Moſes Ben-Maimon. of the Rabbies tells us, that the king (as indeed God uſually charges eminence of place with eminence of piety) was bound to write it out himſelf, and that, as king. For though before his aſcending the throne, as any other Iſraelite, he had a tranſcript of his own writing; yet was there annexed to the acquiſt of the regal ſcepter a duty of copying with the ſame hand that ſwayed it. To *Joſhua* both a general and a judge, who was to wield the ſwords both of *Aſtræa* and of *Bellona*, to govern one numerous people, and conquer ſeven; the words
Joſh. i. 8. of God are very remarkable: *This book of the law ſhall not depart out of thy mouth, but thou ſhalt meditate therein day and night, that thou mayeſt obſerve to do according to al that is written therein; for then thou ſhalt make thy way proſperous, and then thou ſhalt have good ſucceſs.* *David* was a ſhepherd, a conqueror, and a king, and had certainly no unfrequent diſtractions, both before he came to the crown, (whilſt he lived a deſpiſed younger brother, an envied courtier, a diffident fugitive, and a diſtruſted captain) and after, whilſt he wore, loſt, and regained it: but how little the time employed in the ſtudy of the ſcripture prejudiced his ſecular affairs, his ſtory and ſucceſſes may atteſt; and how large a portion of his time that ſtudy ſhared, you may be plentifully informed by himſelf, and ſave me the tranſcribing much of the book of *Pſalms*. He gathered bays both on *Parnaſſus* and in the field of honour; and equally victorious in duels and in battles, his exploits and his conqueſts were ſuch, as (tranſcending thoſe in romances almoſt as much in their ſtrangeneſs as their truth) needed an infallible hiſtorian to exact a belief, their greatneſs and their number would diſſuade. He added to his regal crown of gold two others (of bays and laurel) which his ſucceſsful ſword and numerous pen, making him both a conqueror and a poet, gained him from victory and the muſes. And yet for all this greatneſs and this fame, and that multitude of diſtractions that ſtill attends them, the (then extant) ſcripture was ſo unſeveredly his ſtudy, and he ſo duly matched in his practice what the Apoſtle couples in his precept, *diligence in buſineſs*, and *fervency in ſpirit*, that it is not Rom. xii.
eaſy fitlier to reſemble him, than to the winged cherubims in the old tabernacle, whom all the gold and jewels, that glittered about them, and all the clouds of incenſe fumed before them, could never divert from a fixed poſture towards the ark of the teſtimony, that contained the Deut. xxv.
law, and the mercy-ſeat that repreſented Chriſt. 18, 19, 20,
And indeed, it is a ſaying equally ancient and 21.
true, that none ſhould know (things better and) better things than princes; for their virtues and their vices participate the eminence and authority of their condition; and by an influential exemplarineſs, ſo generally faſhion and ſway their ſubjects, that as we find in ſacred ſtory, that the Jews ſerved God or *Baal* as their kings did, ſo profane hiſtory tells us, that *Rome* was warlike under *Romulus*, ſuperſtitious under *Numa*, and ſo ſucceſſively moulded into the diſpoſitions of her ſeveral princes; ſubjects, all the world over, being apt to think imitation a part of the duty of obedience; and being generally but too ſenſible of the requiſiteneſs of their being like their prince to the being liked by him. A ſtate, like *Nebuchadnezzar*'s myDan. ii,
ſterious image, ſhould have the head of gold; 31, 32,
and the inferior members of a value proportionate to their vicinity to that nobleſt part. &c.
When once I ſhall ſee ſuch monarchies and common-wealths no rarities, and ſee the addictedneſs of princes to the ſtudy of ſcripture further the ulterior accompliſhment of that part of it, which once promiſed God's people,
that kings ſhould be its nurſing fathers, and Iſa. xlix.
their queens its nurſing mothers; I ſhall expect 23.
to ſee the golden age elſewhere than in poets dreams. For I take not abſoluteneſs to be like a plague, whoſe almoſt boundleſs power is confined to do miſchief; but I eſteem ſovereignty little leſs applicable and effectual to good than ill. *Trajan* and *Conſtantine* were

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as great and publick bleſſings, as *Nero* or *Caligula* were miſchiefs; and virtue on a throne hath not a much leſs imperious influence, than crowned vice. And accordingly I ſhall permit my good wiſhes for mankind to turn expectations, when I ſhall generally ſee ſove-
Pſal. cxiii. reigns nobly contend for as great a ſuperiority over each other by their virtues, as they poſſeſs over their ſubjects by their fortune; when I ſhall ſee potentates make uſe of *Mars*'s ſword but to reſtrain others from abuſing it; and kings affect their reſemblance to God, leſs in his unlimitedneſs of power, than his employment of it. But, to ſtep back into my way, and leaving princes to fitter monitors, ſay ſomething to men of either great titles or employments. There is none of theſe pragmatical perſons, that will ſuffer himſelf to be ſo enſlaved to his buſineſs, but he will allow himſelf ſet times, and can daily find leiſure for eating, drinking, and other corporal refections, and frequently for recreations: and certainly, if we valued not our bodies above our ſouls, we would, in ſpite of the urgency of ſecular affairs and employments, reſerve and ſet a part ſome time to feed our ſouls with their true food, God's word; elſe we ſhall never be able to ſay of God with holy *Job*,
Job xxiii. 12. *I have eſteemed the words of his mouth more than my neceſſary food.* I will not urge, that *Daniel*, whoſe vaſt abilities had a reſembling theatre, and who ſurpaſſed other ſtateſmen as
Dan. vi. 3. much in the number and weight of the affairs he had to manage, as in the excellent ſpirit and dexterity, wherewith he managed them, amidſt tranſactions that buſied ſixſcore princes, who loaded him with a weight (of buſineſs) capable to have cruſhed *Atlas*, could yet find
Dan. ix. 2. leiſure to ſtudy the prophet *Jeremy*; becauſe it will be perhaps more proper to mention, that even *Machiavel* himſelf, that ſecretary and reputed oracle of ſtate, could find time, not only to read, but to write plays, (ſome of which I have ſeen in Italian) ſuch as I would not think excellent, though a perſon, from whom ſo much might be expected, had not written them. Let us not then think our buſineſs or our recreations a ſufficient diſpenſation from an employment, for which, were they inconſiſtent, they ought both to be declined; ſince it is both more concerning than the firſt, and more ſatisfying than the latter. But that, which is often the true, though ſeldom the avowed cauſe of theſe men's neglect of the ſcripture, is not their unleiſuredneſs, but their pride; which makes them think it too mean, and trivial an employment for one, that is great and wiſe enough to counſel and converſe with princes; and have a vote or hand in thoſe great enterprizes and tranſactions, that make ſuch a noiſe in the world, and are the loud themes of the people's talk and wonder, to amuſe themſelves to examine the ſignifications of words and phraſes. For my part, I am no enemy to the calling of ſtateſmen; I think their profeſſion as requiſite as others in a commonwealth; and ſhould think it very injurious to deny them any part of a purchaſe they pay their care and time for: nor perhaps have I ſo little ſtudied the improvements of quiet, as to think my ſelf leſs obliged than others are to thoſe, whoſe watchings or protection affords it, or ſecures it to me. But after all this is ſaid, I love to look upon the world with his eyes, that is juſtly ſaid to *humble himſelf* (when he vouchſafes) *to behold the things that are done in heaven and in earth*; and to take meaſure of the dimenſions of things by the ſcale his word holds forth. Now in the eſteem of him, that hath made all things for himſelf, and of whom his ſpirit by his prophet truly ſays, that the *nations are as a drop of a bucket, and* Iſaiah xl. *are counted as the ſmall duſt of the balance*; nay, 13, 17. that *all nations before him* (are) *as nothing, and they are counted to him leſs than nothing and vanity*; the importanteſt employments are the ſtudy and glory of God. He created this vaſt fabrick of the world to manifeſt his wiſdom, power, and goodneſs; and in it created man, that it may have an intelligent ſpectator, and a reſident, whoſe rational admiration of ſo divine a ſtructure may accrue to the glory of the omniſcient and almighty architect. And as he created the world to manifeſt ſome of his attributes, ſo doth he uphold and govern it to diſcloſe others of them. The revolution of monarchies, the fates of princes, and deſtinies of nations, are but illuſtrious inſtances and proclamations of his providence. The whole earth once periſhed by water, to ſignalize his juſtice on his enemies; and the whole world ſhall one day periſh by fire, to (exerciſe that former attribute and) evidence his goodneſs to his children: for whom his faithfulneſs to his promiſes will oblige him to build a glorioufer manſion for ſuch glorified reſidents. The angels, ſome of whom the viſions of *Daniel* repreſent to us at the Dan. x. helm of kingdoms and of empires, and whoſe 13. power is ſo great, that one of them could in one night deſtroy a force, capable, if divided, to have made half a dozen formidable armies; 2 Kings theſe glorious ſpirits, I ſay, whoſe nature ſo xix. 35. tranſcends ours, that the very devil cannot, without the aſſiſtance of virtue, deſpiſe the objects of our ambition by a ſuperiority of nature only; for all their high prerogatives and employments, think the myſteries unfolded in ſcripture worthy their bowing as well as παρακύπτειν deſire to look into; think not themſelves too 1 Pet. i. eminent to be meſſengers and heralds, of which 12. fond mortals think themſelves too eminent to read; and (being all *miniſtring ſpirits ſent forth* Heb. i. 14. *to miniſter to them who ſhall be heirs of ſalvation*;) diſdain not to think our inſtruction worth their concern, whilſt we diſdain a concern for our own inſtruction. Nay, the very Meſſias, whoſe ſtyle is *king of kings, and lord of lords*, though he be Rev. xvii. not recorded to have ever read but once, did 14. yet read the ſcripture, and think it worthy his Luke iv. expoſitions and recommending; and well may 17. &c. any think that book worth the reading, that God himſelf thought worth enditing. When *Moſes* and *Elias* left their (local, not real) heaven, and appeared in glory to converſe with our transfigured Saviour on the mount; their diſcourſe was not of the government of kingdoms, or the raiſing of armies for ſubverſion of empires; or of thoſe other ſolemn trifles, which

which heaven places as much beneath men's thoughts as residence; but of (the inspired book's chief theme *his decease, which he should accomplish at* Jerusalem. And after that St. Paul *had been caught up to the third heaven*, and had been blest and refined with his ineffable entertainment there; I wonder not to find him profess so resolutely, that he *counteth all things but loss for the excellency of the knowledge of Christ Jesus his lord*, in whom *faith cometh by hearing, and that hearing, of the word of God*; and who addresses men to the scriptures, as those which testify of him. And perhaps our Saviour used so frequently to conclude his divine discourses with that just epiphonema, *he that hath ears to hear, let him hear*, but to teach us, that there is no employment of our faculties, that more deserves their utmost attention, than the scrutiny of divine truths. That which is pretended to by this discourse, is to impress this truth, that where God is allowed to be an intelligent and equal valuer of things, a man cannot have so great an employment, as to give him cause to think the study of the scripture a mean one; since, thus saith the Lord, *Let not the wise-man glory in his wisdom, neither let the mighty-man glory in his might; let not the rich man glory in his riches: but let him that glorieth, glory in this, that he understandeth and knoweth me.* For sure, if the knowledge of God be so glorious a thing, the study of that book, whence that knowledge is extracted, and where it is most refulgent, is not a despicable employment. Which sure (to add that upon the by) it is somewhat injuriously thought by those, who are so industrious and proud in profane histories and other political books, to discover (or even guess at) those intrigues, which commonly but tell us, by what crafty arts a knave cousened a fool. Nor (to mention this by the by) even in relation to his own profession, is the scripture unable to recompence the study of a Christian statesman; for to omit the (perhaps too) extolling mention *Machiavel* himself makes of *Moses* amongst the famousest legislators; the historical part of the bible being indited by an omniscient and unerring spirit, lays clearly open the true and genuine causes of the establishment, flourishing and vicissitudes of the princes and common-wealths it relates the story of. Whereas other histories (for reasons insisted on in other papers) are liable to great suspicions in the judgment of those, that duly ponder the several narratives made often of the same transaction or event by several eye-witnesses; and that the true secret of counsels is so closely locked up, or so artificially disguised, that to have interest enough to discern (what statesmen mind and build on) the truth and mystery of affairs, one must be biassed and engaged enough to be shrewdly tempted to be a partial relator of them. But, *Theophilus*, I perceive I have slipped into too long a digression; which yet I hope you will pardon as the effect of an indiscreet, perhaps, but however a great concern for a person, to whom nature, education, and fortune have been so indulgent, that I cannot but look upon his condition as liable to the temptations, which either parts or employments singly, and much more both together, are wont to expose men to.

The apologist for and apologist of Romances.

The fifth and last answer to the last objection

You may remember, *Theophilus*, that among the answers, which, I told you, might be made to those, that objected again the scripture, *That it is so unadorned, and so ill furnished with eloquent expressions, that it is wont to prove inefficacious, especially upon intelligent readers*; the fifth and last was this, *That it is very far from being agreeable to experience, that the style of the scripture does make it unoperative upon the generality of its readers, if they be not faultily indisposed to receive impressions from it.*

To make good this reply, I must take notice to you, that that part of the objection, which intimates, that intelligent readers are not wont to be wrought upon by the scripture, has been in great part answered already: for I have lately observed to you, that as it may be granted, that some witty men, who have read the scripture, have, instead of admiring it, quarrelled with it; so it cannot be denied, that many persons as eminent for wit as they, have, upon reading it, entertained a high veneration for it. So that I see not, why the celebrations of those wits, that admire it, may not counter-balance the dis-respects of those, that cavil at it; especially if we consider, that as to most of those, that are looked upon as the witty disregarders of the scripture, scarce any thing, so much as the vanity and boldness of owning that they disregard it, makes them (but undeservedly) be looked upon as wits.

But to this I shall now add, that whereas the objection speaks of intelligent readers, the greatest part of such have not that quickness, which is wont to make men pass for wits, though they may have other abilities more solid and desirable: and yet that the bible has a great influence upon this latter sort of intelligent readers, I presume you will easily believe, if you consider how many great scholars, not only professed divines, but others, have by their learned comments and other writings, endeavoured either to illustrate, or recommend the scripture; and how much a greater number of understanding and sober men, that never published books, have evinced the scripture's power over them, partly by their sermons and other discourses, publick and private; and partly by endeavouring to conform their lives to the dictates of it. Which last clause I add, because you can scarce make a better estimate of what power the scripture has upon men, than by looking at what it is able to make them part with. For not to anticipate what we shall ere long have occasion to mention, let us but consider, what numbers of intelligen tpersons almost every age, without excepting our own, (as degenerate as it is) has produced, who have been taught and prevailed with by the scripture, and considerations drawn thence, to renounce all the greatest sinful pleasures, and embrace a course of life, that oftentimes exposes

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poſes them to the greateſt dangers and very freequently to no ſmall hardſhips.

AND indeed there is ſcarce any ſort of men, on which the ſcripture has not had notable influence, as to the reforming and proving many particular perſons, belonging to it; and to the giving them an affectionate veneration for the book, whereunto they owed their inſtruction. The accounts eccleſiaſtical hiſtory gives us of the rate, at which devout perſons, both in former and latter ages, would purchaſe the bible, when it was dangerous and perhaps capital to be found poſſeſſed of it, would, if I ſhould here repeat them, much confirm what I ſay, and might equally create our wonder and our bluſhes. Thoſe ſorts of profeſſed Chriſtians, that ſeem the moſt evidently to be liable to temptations to neglect or diſregard the ſcripture, are either thoſe, that do, or would paſs for wits, or thoſe that live in courts; the former oftentimes thinking themſelves too wiſe to be taught, eſpecially by a book they think not eloquent, and among the latter there being but too many, whoſe pleaſures are ſo bewitching, or ſo dear to them, that they like nothing, that would divert, much leſs divorce them from their purſuit; or elſe whoſe buſineſs is ſo much, and perhaps ſo important, that they have not leiſure enough to learn, or have too much pride to think they need do it. But yet even among thoſe, that have worn crowns either of gold or bays, or (what perhaps ſome value above both) of myrtle, the bible has not wanted votaries: for not to repeat the names of thoſe, whom I have formerly mentioned to have been as well lovers of the ſcripture, as favourites of the muſes, among the other ſort of men, *thoſe that* (to ſpeak in our Saviour's terms) *are gorgeouſly apparelled, live delicately, and are in kings courts*, there have been divers perſons, upon whom the power of the ſcripture has been almoſt as conſpicuous, as their ſtation among men. I will not mention that devout treaſurer of the *Æthiopian* queen, who even upon the high-way (whoſe length neither deterred nor tired his devotion) could not forbear to read the prophet *Iſaiah*, and inquire even of a meer ſtranger, that paſſed by alone, and on foot, the meaning of a paſſage, of whoſe ſenſe he doubted; nor will I urge any other inſtances of great men's ſtudiouſneſs of the ſcripture, afforded us by ſacred ſtory. And therefore I ſhall not preſs the example of that great and wiſe *Daniel*, whoſe matchleſs parts not only caſt upon him the higheſt employment of the world's monarchy, and diſengaged him from the ruins of it; but (what has ſcarce a precedent amongſt the very wiſeſt ſtateſmen) continued him in as much greatneſs, as ever he poſſeſſed under the predeceſſor, under the ſucceſſor; and ſuch a ſucceſſor too, as made his predeceſſor's carcaſs the aſcent to his throne: I will not, I ſay, at preſent urge the examples extant in the ſacred records of great men's ſtudiouſneſs of them, becauſe even ſecular and more recent hiſtories may inform us, that even in courts all men's eyes have not been ſo dazzled by the glittering vanities, that are wont to abound there, but that ſome of them have diſcerned, and practically acknowledged the perogatives of ſcripture. Though I cannot ſay, that many kings have been of this number, becauſe there have been but few kings in all, in reſpect of the numbers, that compoſe the inferiour conditions of men; yet even among theſe, and in degenerate ages, ſome have been ſignally ſtudious of the bible; ſuch was that ſixth *Edward*, who imitated the early active piety of *Joaſh*, without imitating his defection from it, and whoſe ſhort heavenly life manifeſted, how ſoon, even amidſt the temptations of courts, grace can ripen men from glory. And ſuch was that learned king, whoſe having more than perfunctorily ſtudied the ſcripture, his ſolid defence of divers of its truths againſt his miſinterpreters have ſufficiently proclaimed to the world. Nay, even in thoſe darker times, that preceded the reformation, that excellent Aragonian king, *Alphonſus*, the honour both of his title and his times, in ſpite of his comtemplations and his wars, could, (as himſelf uſed to glory) ſpare time from ſtudies and his diſtractions, to read the bible forty times with comments and gloſſes on it; being not, for all his aſtronomy, ſo taken up with contemplation of heaven, as to deny himſelf leiſure to ſtudy in his book, that made it, the ways of getting thither. Nor ſhall I forbear to mention here the laſt pope (*Urban* the eighth) who, when being cardinal, he wanted not the hopes of becoming both temporal and eccleſiaſtical lord of that proud city, which (as if ſhe were deſigned to be ſtill, one way or other, the world's miſtreſs) doth ſtill rule little leſs of the world upon the ſcore of religion, than ſhe did before upon that of arms; in the midſt of affairs, perhaps more diſtracting than buſied moſt potentates, and honours almoſt as great as are paid to monarchs, could find room in a head crouded with affairs enough to have diſtreſſed *Machiavel*, for reflections upon the ſcripture; ſome of whoſe portions I have delighted to read in the handſome paraphraſes of his pious muſe. Which I ſcruple not to acknowledge, becauſe that though I did, which I do not, look upon every one, that diſſents from me, as an enemy; yet I ſhould be apt to think, that they can ſcarce love virtue enough, that love it not in their very enemies; congruouſly to which we find that *Hannibal* had ſtatues erected in *Rome* it ſelf; and though I were ſo uncharitable and ſo unexperienced as to think a man, that holds an error, can ſcarce have any good qualities; yet upon ſuch a kind of ſcore as that, which made *David* ſo angry with him, that took away the poor man's ſingle lamb, the fewer commendable qualities I ſee in my adverſaries, the more ſcruple I would make to rob them any way of them. Nor hath that very ſex, that ſo often makes divertiſements of its employments, been altogether barren in titled votaries to the ſcripture. Not to mention that Grecian princeſs, whoſe proſelyted muſe made *Homer* turn evangeliſt, how converſant that excellent mother and reſembling daughter, *Paula* and *Euſtochium*, were in the ſacred rolls, is ſcarce unknown to any, that are not ſtrangers to the writings of St. *Hierome*;

Luke vii. 25.

King *James*.

Eudoxia *wife to the Emperor* Theodoſius.

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for ſome of whoſe learned comments on the ſcripture we are endebted to the charitable importunity of their requeſts. And even in our times, that ſo much degenerate from the primitive ones, how eminent a ſtudent and happy a proficient in the ſtudy of the bible, that glory of princeſſes, and the envy of the princes of her time, queen *Elizabeth*, was, her life and reign ſufficiently declare. Her ſiſter's predeceſſor, that matchleſs lady *Jane*, who had all the good qualities the beſt patriots could deſire in a queen, but an unqueſtionable title, and in whoſe ſad fate, beſides her ſex and the graces, that enamour ours of it, her country, philoſophy, virtue, and religion, did all ſuſtain a loſs, was a conſpicuous ſtudier of the inſpired books; wherein her proſpered ſeduloufneſs gave her an underſtanding much above her age and ſex, though not above her virtue. And beſides *Eudoxia*, there have been divers other perſons of the higheſt quality of that ſex, and even ſome of thoſe, on whom nature or fortune, or rather beauty or providence had conferred a ſovereignty, whom the ſplendour, the pleaſures, nor the avocations of courts could not keep from ſearching in God's word preſervatives againſt the contagion of their condition. And partly hiſtory, and partly even converſation have ſometimes with delight made me obſerve, how ſome of thoſe celebrated ladies, whoſe fatal beauties have made ſo many idolaters, have devoutly turned thoſe fair eyes, that were, and did ſuch wonders, upon thoſe ſevere writings that depreciate all but the beauty of the ſoul, from thoſe flattering aſcriptions, that deified the body. And it is not to be marvelled at, that ſuch readers as are not infidels, by reading the bible once, ſhould be prevailed with to read it oftener; not only becauſe of the inviting excellency of what it teaches, but becauſe its author does ſo earneſtly in it enjoin the ſtudy of it, that ſcarce any can think the neglect of it no fault, ſave thoſe that are guilty of it. Nor is their ſo aſſiduous peruſal of the ſcripture ſo much to be marvelled at as commended, in perſons of that ſofter ſex, which is perhaps more ſuſceptible than ours of ſtrong impreſſions of devotion. For ſure, if we loved God, I do not ſay as we ought to love him, but as we can, and do love inferiour things, it would hugely endear the ſcripture to us, that the object of our devotion is the author of that book. When a true flame, though but for a fading object, doth once poſſeſs a fervent lover's breaſt, what a fondneſs doth his paſſion for his miſtreſs give him for all things related to her? Her reſidencies, her walks, her colours, and the leaſt trifles that have belonged to her, exact a kindneſs that's not due to trifles; though it be but for preſenting to his memory its almoſt only object, and refreſhing him with an ideal in the abſence of an immediater preſence of her. But if the favoured amouriſt be bleſt with any lines dignified by that fair hand, (give me leave to talk of lovers in their own language) eſpecially if they be kind as well as hers, how aſſiduouſly, and with what raptures do his greedy eyes peruſe them, taſting each ſeveral expreſſions with its own tranſport; and finding in each line, at each new reading, ſome new delight or excellency? This welcome letter grows ſooner old than ſtale; and all his too frequent kiſſes have worn it to tatters, (in which he preſerves it, if not worſhips too, as a relic) with ſtill freſh and ſtill inſatiate avidities doth the unwearied lover prize that (too often, either deluding or inſignificant) writing, above the nobleſt raptures of poets, and liberalleſt patents of princes: and (not to urge the ſuperſtitious devotion of our worſhippers of relicks) certainly if we had for God but half as much love as we ought, or even pretend to have, we could not but frequently (if not tranſportedly) entertain our ſelves with his leaves, which (as parrhelions to the ſun) are at once his writings and his picture; both expreſſing his vaſt and unmerited love to us, and exhibiting the moſt approaching or leaſt unreſembling idea of our beloved, that the Deity hath framed for mortals to apprehend. It was the devout quarrel of a devout father to ſome of the choiceſt compoſures antiquity hath left us, that he could not find Chriſt named there; and if, as it is not to be doubted, divers of the devout ladies I was lately ſpeaking of, were of his mind, ſure at that rate they are not ordinarily kind to the ſcripture; where the Prophets and the Apoſtles, thoſe darker and more clear Evangeliſts, do ſo unanimouſly and aſſiduouſly celebrate the Meſſiah, that when I read and confer them, I ſometimes fancy my ſelf preſent at our Saviour's triumphant entrance into *Hieruſalem*, where both *thoſe that went before him, and thoſe that followed after him, ſung hoſannah to the ſun of* David.——Wherefore, ſince even great wits, great princes, and great beauties, have not ſtill by all thoſe temptations, to which theſe attributes expoſed them, been kept from being alſo great votaries to the ſcripture, it cannot charitably be doubted, but that in moſt ages ſome pious perſons have been able to ſay truly to God in *Jeremy*'s terms, *Thy words were found, and I did eat them; and thy word was to me the joy and rejoicing of mine heart.* And if the perſons I mention have been but few, I can attribute that fewneſs but to the paucity of wiſe and good men; and as for perſons of other ranks in eccleſiaſtical ſtories, the inſtances are not ſo rare of the addictedneſs of God's children to his word, but that we might thence produce them almoſt in throngs, if we had not nobler inducements to the reading of the inſpired volume than example; and if it were not leſs to be venerated, becauſe ſo many ſaints have ſtudied it, as becauſe the ſtudy of it made many of thoſe men ſaints, (I mean not nominal, but real ones:) which we need not much wonder at, whilſt ſuch a ſaint as Saint *Paul* was aſſures us, that it is all of it divinely inſpired, and improveable to all the uſes requiſite to the entire accompliſhment of God's ſervants. But *Theophilus*, to return to what I was formerly diſcourſing of, the transforming power the ſcripture has upon many of its readers; I muſt ſubjoin, that though through the goodneſs of God theſe be far more numerous than the profeſſed adverſaries

Mat. xxi. 9. Mark xi. 9.

Jerem.xv. 16.

2 Tim. iii. 16.

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ſaries and contemners of the ſcripture, yet theſe make not ſo great a part of thoſe, that acknowledge the bible, as it were well they did, becauſe both experience and our Saviour's parable have ſufficiently taught us, that good ſeed does not always fall into good ground, and that many intervening accidents may, after it has been ſown, make it miſcarry and prove fruitleſs. But when you find (as I fear you may but too often) that the ſcripture has not upon its readers, and eſpecially upon thoſe that are profane, that power, which I ſeem to aſcribe to it, and which it ought to have; you may be pleaſed to remember, that I plainly ſuppoſe in my fifth anſwer, that thoſe, to whom the ſcripture is addreſſed, muſt not be culpably indiſpoſed to be wrought upon by it. Which that profane perſons are, I preſume you will eaſily grant: for when our Saviour ſaid, that *if any man will do the will of him that ſent him, he ſhall know of the doctrine, whether it be of God, or no*; he clearly intimates, that there is required a diſpoſition as well in the eye of his ſoul, (if I may ſo ſpeak) as in the object propoſed, to make a man diſcern the excellency and origination of what is taught, how valuable ſoever. St. *Paul* ſpeaking of himſelf and other penmen and teachers of the ſcriptures, affirms, that they ſpeak wiſdom among them, that are perfect, and (though not this world's wiſdom, yet) *the wiſdom of God in a myſtery, even that hidden one, which God ordained before the world, unto our glory.* But for theſe ſcorners, it is no wonder they ſo fruitleſly read the ſcripture, without deſcrying any of this myſterious wiſdom, it being a ſentence of the ſcripture it ſelf, *that a ſcorner ſeeketh wiſdom, and [findeth it] not*, (the expreſſion is odd in the original, but I muſt not ſtay to deſcant upon it;) as the Sodomites could not find the angels, when once they ſought them to proſtitute and defile them.

John vii. 17.

1 Cor. ii. 7.

Prov. xiv. 6.

Gen. xix. 5, 11.

BUT beſides profane wits, there are too many other readers, who are (more or leſs) guilty of oppoſing the reforming and improving influence of the ſcripture, upon their own hearts; either upon the ſcore of their not ſufficiently believing the truths contained in the ſcripture, or upon that of their not duly pondering them. That unbelief is the fruitful mother of more ſins than are wont to be imputed to it, and that many baptized perſons are not free from greater degrees of it, than they are ſuſpected of by others, or even by themſelves, I could here eaſily manifeſt, if I had not profeſſedly diſcourſed of that ſubject in another place. And indeed, there needs but a comparing of moſt men's lives with the promiſes and threats held forth in the ſcripture of no leſs than everlaſting joys and endleſs torments, to make us believe, that there are multitudes of profeſſed Chriſtians, to whom may be applied what the writer to the Hebrews ſays of the perverſe Jews of old, *That what they heard did not profit them, not being mixed with faith in them that heard it*, or (as the Greek will bear) becauſe they were not united by faith to the things they heard. But this is not all, for oftentimes the doctrines of the ſcripture loſe much of their efficacy, even where they are cordially believed, becauſe they are not ſufficiently laid to heart. The diſparity of the influences of the bare belief and the due perpenſion of a truth is, methinks, conſpicuous enough in men's thoughts of death. For though that they ſhall die is ſo truly believed, that it cannot ſeriouſly be doubted; yet how doth men's inadvertency make them live here, as if they were to do ſo always? Whereas when once grace, ſickneſs, the ſight of a dying friend, or ſome other tragick ſpectacle, hath ſeriouſly minded them of death, it is amazing to obſerve, how ſtrange an alteration is produced in their lives by the active and permanent impreſſion of that one obvious and unqueſtioned truth, that thoſe lives muſt have a period; and to ſee how much the ſober thoughts of death contribute to fit men for it: it being ſo imperious an inducement to deny ungodly and worldly luſts, and to live σωφρόνως καὶ δικαίως καὶ εὐσεβῶς ἐν τῷ νῦν αἰῶνι, *ſoberly, righteouſly, and godly in this preſent world*, that we muſt one day leave it; that I admire not much that father's celebrated ſtrictneſs and auſterity, who tells us, that he fancied always ſounding in his inward ears, that dreadful alarm of, *Surgite mortui, & venite ad judicium.*

Heb. iv. 2.

Tit. ii. 12.

YET notwithſtanding the indiſpoſition of many readers to reverence and obey the ſcripture, and notwithſtanding that in divers paſſages of it, the ornaments of language are (for reaſons above ſpecified) purpoſely declined; yet we find not, but that the ſcripture, for all theſe diſadvantages, is by the generality of its readers both eſteemed and obeyed at another-guiſe rate, than any other book of ethicks or devotion. And multitudes even of thoſe, whoſe paſſions, or intereſts, will not ſuffer them to be in ſome points guided by it, are notwithſtanding ſwayed by it, to forbear or practiſe divers things, in caſes wherein other books would not prevail with them. As *Herod*, though the Baptiſt could not perſuade him to quit his *Herodias*, did yet, upon *John*'s preaching, do many other things, and *heard him gladly.*——I was going to ſay, that we may not unfitly apply to the word of God, what divines have obſerved of God the word; for as thoſe accidents, that loudlieſt proclaimed our Saviour's having aſſumed our human nature and infirmities, were attended with ſome circumſtances, that conſpicuouſly atteſted his divinity; ſo in thoſe paſſages, in which the majeſtyof the author's ſtyle is moſt veiled and diſguiſed, there is yet ſome peculiarity that diſcloſes it. But I ſhall leſs ſcruple to tell you, that in divers of thoſe paſſages, in which the Holy Ghoſt (who in the Greek fathers wonted expreſſion does often συγκαταβαίνειν ἡμῖν, ſtoop to our capacity, and, as it were, ſink himſelf down level,) ſeems moſt to have vouchſafed a condeſcenſion to the ſtyle of men; and to have commanded his ſecretaries, as he once did the prophet *Iſaiah*, to write, בחרט אנוש *Be-chæaet Enoſh, with a man's pen*; in divers of thoſe very places, I ſay, there is ſomething of ſo aweful, and ſo peculiarly his, that as the ſun, even when he deſcends into the Weſt, remains ſtill lucider than any of the ſtars; ſo the divine inſpirer of the

Mark xii. 37.

Iſa. viii. 1.

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the ſcriptures, even when his ſtyle ſeems moſt to ſtoop to our capacities, doth yet retain a pre-
Acts xv. 18. rogative above merely human writings. *Known unto God are all his works from the beginning of the world*, ſays an Apoſtle; and God, whoſe attribute is to be καρδιογνώστης, *the knower of*
Acts i. 24. Zech. i. 1. Pſal. xiii. 2. *hearts*, and whoſe prerogative it is to *form the ſpirit of man within him, underſtandeth our thoughts afar off.* Certainly then, if we conſider God as the creator of our ſouls, and ſo likelieſt to know the frame, and ſprings, and nature of his own workmanſhip; we ſhall make but little difficulty to believe, that in the book written for, and addreſſed to men, he hath employed very powerful and appropriated means to work upon them. And in effect, there is a ſtrange movingneſs, and, if the epithet be not too bold, a kind of heavenly magick to be found in ſome paſſages of the ſcripture, which is to be found no where elſe; and will not eaſily be better expreſſed, than in the pro-
Heb. iv. 12. per terms of the ſcripture: *For the word of God*, (ſays it) *is quick and powerful, and ſharper than any two-edged ſword, piercing even to the dividing aſunder of ſoul and ſpirit, and of the joints and marrow, and is a diſcerner of the thoughts and intents of the heart.* Wherefore, that *Junius*, (as himſelf relates) was converted from a kind of atheiſt to a believer, upon the reading the firſt chapter of *John*; that a Rabbi, by his own confeſſion, was converted from a Jew to a Chriſtian, by the reading of the fifty-third of *Iſaiah*; that St. *Auſtin* was changed from a debauchee into a ſaint, by that paſſage of the 13th to the *Romans* and 13th verſe; and that another father, whoſe fear had made him diſclaim his faith, burſt out publickly into a ſhower of tears, upon the occaſional reading of the 16th verſe of the 50th *Pſalm*; are effects, that I do not ſo much admire, as I do, that ſuch are produced no oftener. And truly for my own part, the reading of the ſcripture hath moved me to more, and ſwayed me more powerfully to all the paſſions it would infuſe, than the wittieſt and eloquenteſt compoſures, that are extant in our own and ſome other languages. Nay, ſo winning is the majeſty of the ſcripture, that many (like thoſe that fall in love in earneſt with the ladies they firſt courted, but out of, what the French call, gallantry,) who began to read it out of curioſity, have found themſelves engaged to continue that exerciſe out of conſcience: and not a few of thoſe, that did at firſt read the new teſtament only to learn ſome unknown language it is tranſlated into, or for ſome ſuch trivial purpoſe, have been by the means, that they elected, carried beyond the end that they deſigned, and met a deſtiny not ill reſembling
Luke xix. *à ver.* 1. *ad ver.* 10. that of *Zacheus*; who climbing up into a ſycamore growing in our Saviour's way, only to look upon him, paſſed thence to be his proſelyte and convert, and to entertain him joy-
Mat. xiii. 19, 20, &c. fully both in his houſe and heart. And though it be true, that the church's teſtimony be commonly our firſt, yet it is not always our chief inducement to believe the divinity of Holy Writ; its own native prerogatives heightning that into faith, which the church's authority left but opinion. To which purpoſe, I remember a handſome obſervation of ſome of the ancients; that the Samaritans, that firſt believed in Chriſt upon the woman's report, when afterwards they were bleſſed with an immediate converſation with himſelf, they exultingly told the woman, *now we believe, not becauſe of thy* John iv. *ſaying; for we have heard him our ſelves, and* 39—42. *know that this is indeed the Chriſt, the Saviour of the world.* For ſo, divers, that firſt believe the ſcripture but upon the church's ſcore, are afterwards by acquaintedneſs brought to believe the ſcripture upon its own ſcore; that is, by the diſcovery of thoſe intrinſick excellencies and prerogatives that manifeſt its heavenly origination.—This ſacred book, even where it hath not embeliſhments of language, doth not want them; being ſo much recommended by its imperious perſuaſiveneſs without them, that it is more ennobled by their needleſſneſs, than it would be, by their affluence. And if to ſome paſſages of ſcripture we muſt apply that of St. *Paul*, (whereby yet he thought to recommend his miniſtry to the Corinthians) *That his ſpeech and his preaching was not with* 1 Cor. ii. *the enticing words of man's wiſdom, but* ἐν ἀποδείξει 1—4. πνεύματος καὶ δυνάμεως, we may alſo remember, that he ſubjoins as the reaſon, that moved him to uſe this plain and unadorned way of teaching his Corinthians, *That their faith might not* Ver. 5. *ſtand in the wiſdom of men, but in the power of God.* And truly the efficacy and operations of the bible, in compariſon of thoſe of all other books, duly conſidered, we may eſteem, that as God oftentimes doth in the ſcripture, what in the ſcripture he is ſaid to do, draw us with the cords of a man, (paſſages wreathed with flowers of rhetorick) ſo is it not unfit, that we ſhould ſometimes employ expreſſions, that carrying away our obedience, our reverence, and our aſſent in ſpite of our indiſpoſitions to them, might manifeſt their derivation from him, who is not tied to ſuch means, as men would think neceſſary, but can compaſs his ends as well by as without any. Nor can I often conſider the inſtances experience affords us of the efficacy of many texts, (which ſome that pretend to eloquence accuſe of having none) without ſometimes calling to mind, how in the book of nature God has veiled in an obſcure and homely ſtone an attractiveneſs (unvouchſafed to diamonds and rubies) which the ſtubborneſt of metals does obſequiouſly acknowledge. And as the loadſtone not only draws what the ſparklingeſt jewels cannot move, but draws ſtronglier where armed with iron, than crowned with ſilver; ſo the ſcripture not only is movinger than the glitteringeſt human ſtyles, but hath oftentimes a potenter influence on men in thoſe paſſages, that ſeem quite deſtitute of ornaments, than in thoſe, where rhetorick is conſpicuous.

I SHOULD now, *Theophilus*, immediately paſs on to the other things I am to diſcourſe to you of, concerning the ſcripture, but that the curioſity, wherewith you are wont to take notice of my practices, and to make inquiries after my private opinions, makes me imagine you telling me, that I do often read, and do much oftener commend books of devotion, not-

The concluſion of one part of the diſcourſe, concerning the ſcripture; and the tranſition to the next.

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notwithſtanding all the prerogatives I have attributed to the ſcripture: wherefore to this I ſhall anſwer, that I eſteem indeed the truths of ſcripture ſo important and valuable, that I cannot be troubled to ſee them preſented to us in variety of dreſſes, that we may the more frequently and the more attentively take notice of them. And though ſome devout compoſures are ſo unſkilfully written, as to be much fitter to expreſs the devotion of the writer, than to excite it in the reader; yet there are others ſo handſomely and ſo pathetically penned, that a good man can ſcarce read them without growing better, and even a bad man muſt be very much ſo, without becoming leſs ſo by peruſing them. Nor do I at all deſign to diſparage books of devotion, when I prefer the ſcripture to them, that being ſo noble and matchleſs a work, that a book may attain to a high degree of excellence, whilſt it remains inferior to the ſcripture, and of whoſe preheminencies I have already on ſeveral occaſions named divers to you; and therefore ſhall at preſent only recommend to your obſervation this one advantage of the ſcripture, even as to thoſe things, that are alſo to be met with in other books of devotion; That if *the words of the wiſe be* (as *Solomon* tells us they are) *like nails faſtened by the maſters of the aſſemblies*, the ſelf-ſame nail muſt enter leſs or deeper, according to the ſtrength of the hand that drives it in; and doubtleſs, any doctrine believed to come from God, in the ſame terms it is delivered to us, is like to be entertained with a deeper and obſequiouſer reſpect; concurrently whereunto, the Apoſtle, to ſet forth the Theſſalonians reception of the goſpel, ſays, *That they received it not as the word of men*, but (*as it is in truth*) *the word of God*. After which, it is no wonder he could immediately ſubjoin, that *it did alſo effectually work in them that believed*. And though it be very true, that the foreignneſs and obſcurity of ſome texts will require, as well as the teeming richneſs of others will bear, their being alledged in words much more numerous than thoſe, whoſe involved or contracted ſenſes they are to diſplay; yet is it alſo as true, that men do not unfrequiently miſtake themſelves in thinking to deliver the Holy Ghoſt's conceptions in fitter terms than his own, the proper preciſe expreſſions of ſcripture being oftentimes ſo pathetical and ſinewy, that he, that ſtretches them, enervates them; and paraphraſes, though handſome, do as much wrong them, as a mixture of ſilver, though no ignoble metal, does wrong an ingot of gold. And though ſome texts like pearls loſe indeed of their beauty, but operate, and are adminiſtered more ſucceſsfully beaten to powder, or with other cordial ingredients made up into a confection; yet divers ſacred expreſſions do like diamonds loſe both their ſparkling luſtre, and engraving faculty, when ground to duſt, and loſe more in their entireneſs and form than can be recompenſed by any addition. And truly, as to my own particular, no book of devotion doth conſtantly affect me ſo powerfully as the bible. And whereas I am of ſo nice a palate, that in my eſteem compoſures of that kind ſtill loſe at the ſecond reading; in the inſpired volume, familiarity breeds not contempt, but reverence, (and I like a book, acquaintance ſtill endears.) When I firſt began attentively to read the ſcripture, and (according to my cuſtom when I read books, whereof I have a promiſing expectation) to mark in the margin the paſſages, that ſeemed to deſerve a peculiar notice or reflection, I marked but here and there ſome verſes in a chapter; but when, upon a greater familiarity with the idiotiſms, the ſenſe, and the applicableneſs of ſcripture, I came to reſurvey it, I then in ſome places marked the whole chapter, and in moſt others left much fewer texts than before unfurniſhed with ſome mark of reference. And whereas at my entrance I took even the choiceſt part of the bible to be at beſt but like ſome Indian province, wherein though mines and gems were more abundant than in other countries, yet they were but ſparingly to be met here and there: after a competent ſtay, my enſuing peruſals preſented it me, if not as a royal jewel made up of gold and precious ſtones, yet (which is glorioufer) like *Aaron's* breaſt-plate, a ſacred jewel, the particular inſtructions, for which were given by God himſelf, and which, beſides the various number of flaming gems ſet in fine gold, and placed in a myſterious order, was ennobled by that *Urim* and *Thummim*, wherein God vouchſafed to reveal himſelf to mortals, and was adorned with ſo much cunning work in gold, blue, purple, ſcarlet, and fine twined linen, that the contrivance and workmanſhip lent a luſtre to the glittering materials, without being obſcured by them. This experiment keeps me from wondering to find in the inſpired poet's deſcription of the man he attributes a bleſſedneſs to, that his *Chaphatz* is in the *law of the Lord, and in his law will he meditate day and night*. For the word other tranſlations render *voluntas & ſtudium*, ours Engliſhes delight; and indeed the Hebrew חכץ will bear both ſenſes, and ſeems there emphatically to ſignify a ſtudy repleniſhed with ſo much delight to the devout and intelligent proſecutors of it, that, like the hallelujahs of the bleſſed, it is at once a duty and a pleaſure, an exerciſe and a recompence of piety. And indeed, if God's bleſſing upon the devout Chriſtian's ſtudy of that book do (according to the Pſalmiſt's prayer) *open his eyes to diſcern the* נפלאות *Niplaot, hidden wonders* contained in it; he ſhould, in imitation of him that in the ſame Pſalm ſays of his God, *I rejoice at thy word, as one that findeth great ſpoil*, be as ſatisfied as navigators, that diſcover unknown countries. And I muſt confeſs, that when ſometimes, with the Apoſtles in the mount, I contemplate *Moſes* and *Elias* talking with Chriſt, I mean the law and prophets ſymphonizing with the goſpel, I cannot but (reſemblingly tranſported with a like motive) exclaim with *Peter*, *it is good for me to be here*; and ceaſe to think the Pſalmiſt an hyperboliſt, for comparing the tranſcendent ſweetneſs of God's word to that inferior one of honey, which is like it in nothing more

Eccleſ. xii. 11.

1 Theſſ. ii. 13.

Pſalm i. 2.

Pſal. cxix. 8.

Verſ. 162.

Mat. xvii. 4.

Pſal. cxix. 103.

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more, than in that, of both their ſuavities, experience gives much advantageouſer notions than deſcriptions can.

BUT, *Theophilus*, upon condition you will not call this excurſion of your own occaſioning a fit of devotion, I will no longer detain you on one ſubject, but forthwith proceed to diſcourſe of thoſe other things, that I am to conſider in the ſcripture, beſides the ſtyle. For though this be ſuch as I have been repreſenting it, yet I hope we ſhall in our progreſs find, that it will be far leſs fit to apply to this matchleſs book that of the Heathen poet,

Materiam ſuperabat opus——

than that ſacred one of the Pſalmiſt, where he as well ſays, that *the king's daughter is all glorious within*, as that *her cloathing is of wrought gold.* Pſal. xlv. 13.

OCCASIONAL

REFLECTIONS

UPON

SEVERAL SUBJECTS.

Whereto is premiſed

A DISCOURSE about ſuch kind of THOUGHTS.

Omnibus rebus, omnibuſque ſermonibus, aliquid ſalutare miſcendum eſt. Cum imus per occulta naturæ, cum divina tractamus, vindicandus eſt à malis ſuis animus, ac ſubinde firmandus. Sen. Natural. Quæſt. Lib. 2. cap. 59.

To *SOPHRONIA.

My deareſt Siſter,

YOU receive, in this effect of my obedience, one of the higheſt proofs I can give you of its greatneſs. For when you command but things, that tend to your ſervice, the performance is wont to be accompanied with a ſatisfaction, that ſuffers me not to find it uneaſy. But I confeſs it was not without reluctancy, that I was prevailed with to venture abroad compoſures, wherein, even when I publiſh them, I decline owning them; and which (if our names be diſcovered) may, I fear, not only hazard the reputation (if it have any) of my pen; but, (where you are leſs known) bring into queſtion that of your judgment. It was eaſy for me to repreſent to you, how unfiniſhed and unpoliſhed the trifles you called for were; eſpecially conſidering, that the immatureneſs of ſome of them would not probably be the chief thing, that would make many think they come forth unſeaſonably, ſince they avowedly aim at the perſuading and teaching men to improve their thoughts, as well as huſband their time, at a ſeaſon, when both thoſe precious things are ſo neglected, or ſo miſ-employed, that the chief uſe, which too many make of the former, is to deviſe ways to get rid of the latter. But though, to my unreadineſs to publiſh theſe very long neglected papers, at the ſame time when a pre-engagement obliged me to diſpatch another treatiſe of a quite different nature, I added all thoſe other diſſuading conſiderations, that I have mentioned in the preface to the reader; yet what I repreſented proved as unavailable, as what I had written was incompleat. For, whilſt you fancied, that the following reflections (ſuch as they are) had fewer faults, and were like to do more good, than I can preſume; your charity for others, and partiality for me, made you ſo reſolute and preſſing to have me run a venture, which you are pleaſed to think but a very ſmall one, that I judged it more excuſable to preſent you green fruit, than, by obſtinately refuſing what you ſeemed almoſt to long for, loſe an opportunity of evincing, that your commands can prevail, both where thoſe of others would have been wholly ineffectual, and when they required me to preſent you (ſome, if not many,) things,

1 that

* It is the name given to the ſame lady in the 2d ſection of the following meditations,

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that are ſo little worthy of you, that perhaps they are ſcarcely ſo, even of me.

WONDER not, dear *Sophronia*, that I appear ſo ſollicitous to manifeſt the greatneſs of my obedience; ſince that implies an urgency in your commands, that is highly concerns me to have taken notice of. For thoſe, that, having the happineſs to converſe with you, ſhall chance to caſt their eyes upon the following papers, will probably think, that I ſhew as little diſcretion in the addreſs, as I have ſhewn ſkill in the writing, of theſe reflections; when I expoſe ſuch cenſurable things to the judgement of a perſon, that has ſo piercing a one, and preſent trifles to one, that deſerves the nobleſt productions of (what ſhe is ſo great a miſtreſs of) wit, and eloquence. Upon whoſe account ſhe is wont to perſuade piety as handſomely in her diſcourſes, as ſhe expreſſes it exemplarily in her actions; and might, if her modeſty did leſs confine her pen to excellent letters, both make the wits of our ſex envy a writer of hers, and keep our age from envying antiquity for thoſe celebrated ladies, who, by their triumphant eloquence, ennobled the people of *Rome*, and taught their children to ſway thoſe rulers of the world.

BUT when I can plead, that not only your commands, but even your importunity ingaged me (though not to the addreſs, yet) to the publication of theſe papers; I may reaſonably hope, that among thoſe many conſiderable perſons, to whom your attainments are not unknown, not only my dedication will be excuſed, but even my book will not be ſo haſtily condemned.

BUT I dare not proſecute ſo fruitful a ſubject, for fear of offending your modeſty; ſince that predominant virtue gives you ſo great an undervaluation for all your other qualities, that it is as much your cuſtom to look even upon ſmall praiſes as flatteries, as it is your prerogative to keep great ones from being ſo. And I ſhould therefore have omitted that little itſelf, which I have ſaid, if, on this occaſion, my intereſt did not as well oblige me, as the known truth warrant me, ſo to conſider your modeſty, as not to be altogether injurious to your other excellencies; ſince the reader's knowledge of theſe (if he be not a ſtranger to you) will promiſe me this advantage, that divers of the criticks themſelves will chuſe rather to abſolve my writings, than condemn your judgment; and that at leaſt the devout, to whom your practice has afforded ſo many other examples, will be ſcrupulous to be more ſevere to theſe papers, than a perſon, in whom, upon the ſcore of her own ſtyle, ſeverity were more juſtifiable than in moſt readers, (without excepting the eloquent ones;) and will imitate her, in conſidering, that this book pretends to preſent them thoughts, rather than words; and in ſupporting, for the ſake of the deſign, the manner, in which it is proſecuted.

AND certainly, my lady *R*'s approbation is a happineſs, which divers ſorts of conſiderations may render as advantageous as welcome to me. For if any of theſe thoughts do (which yet I can ſcarce hope) derive it from your juſtice, that great meaſure of eſteem you do not only merit, but poſſeſs, may both aſſure them of a general one, and much contribute to procure it them. But if all of them owe your approbation (as I fear they do) to your partiality; ſince that muſt not be ſmall, to be able to pervert ſuch a judgment, this it ſelf will prove an evidence of the bleſſing of your affection; which is a felicity, that I know you enough to value above all the praiſes I can miſs of: ſince applauſe can make me happy but in other men's opinion, but your friendſhip can make me ſo in my own. Yet, apprehend not, ſifter, that I ſhould here endeavour, by a ſolemn character of you, to juſtify what I have been ſaying; for, though to write a dedicatory epiſtle, without a panegyrick, be grown of late very unfaſhionable; yet ſince it is as much ſo, to take the praiſes wont to be profuſely given in ſuch letters for meaſures of any thing but the writer's wit, I muſt rather reſerve the acknowledgments I owe your merit and your favours, to ſome occaſion, where they may not be liable to paſs for a tribute paid to cuſtom, not a debt due to you, than draw a needleſs ſuſpicion upon the ſincerity of our friendſhip, by endeavouring to expreſs my affection and eſteem in a dedicatory letter; and by chuſing to profeſs, upon an occaſion where cuſtom allows men to ſay what they do not think, ſo great and real a truth, as that of my being, far more upon the account of eſteem and gratitude, than of nature it ſelf,

My deareſt Siſter,

Your moſt affectionate,

and moſt faithful Servant,

R. B.

An

An Introductory Preface.

WHEN I conſider the diſadvantages, with which the following trifles come abroad, in an age, that is not only ſo cenſorious, but ſo intelligent, as this of ours; neither the partiality of my friends, nor the favourable reception, that the publick has hitherto vouchſafed to what hath been preſented it of mine, is able to give me a confidence, (though they almoſt create a hope) that theſe papers will meet with as kind an entertainment, as thoſe of the ſame hand, that have preceded them. And yet, without being wanting to my ſelf, I cannot but add, that by the help of their ſuggeſtions, who have urged the publication of theſe thoughts, I am not unfurniſhed with (at leaſt) tolerable excuſes for the things, that ſeem likely to ſtand in need of any.

I Shall not much wonder to find it ſaid, that the book is, in general, far ſhort of being an exact and finiſhed piece. For perhaps few readers will be more of that mind, than the author is. But by way of apology, it may be repreſented, that moſt of the following papers being written for my own private amuſement, a good deal of negligence in them may appear as pardonable, as a careleſs dreſs, when a man intends not, nor expects, to go out of his ſtudy, or let himſelf be ſeen. And that which I now publiſh being deſigned, not to ſatisfy the criticks, but to gratify the devout, I hope it will be thought a venial crime, if in ſome of theſe meditations I have not aimed to expreſs eloquence, but only to cheriſh piety. I ſay in ſome, becauſe there may be others (where a different ſtyle was thought fitter) in whoſe favour I would produce ſuch ſuffrages, as would not be ſlighted, if I were concerned to do any more for thoſe papers, than excuſe them.

And perhaps they, that ſhall take the pains to try their ſkill in making meditations indifferently upon the occurrences that ſhall happen, and wander no farther from the circumſtances of their themes, nor lard them any more with ſentences and other paſſages borrowed from the fathers, or the poets, than in moſt of the following papers I have done; will not find the taſk ſo eaſy, but that they will think it reaſonable to be mild in their cenſures, and will diſcern, that in ſuch compoſures, ſome unaccurateneſs is ſo hard to be avoided, that it ſhould not be hard to be forgiven.

I Know the want of uniformity in the ſtyle of the enſuing reflections may ſpeciouſly enough be cenſured. For, not to mention, that ſome of them are very long, and others very ſhort; it will be ſaid, that ſome are written in a very neglected, and others even in a luxuriant ſtrain; and there may (perchance) appear betwixt ſome of them as great an inequality as can eaſily be found betwixt compoſures, that are none of them excellent. Beſides that the incoherence of the ſubjects, together with the differing ways wherein they are handled, may make them look ſo little of kin to one another, as ſcarce to appear the productions of the ſame pen. But this uneven way of writing will poſſibly be rather pardoned than wondered at, by thoſe, that ſhall be informed,

That the nature of this kind of compoſures requires not any other, than a looſe and deſultory way of writing.

That theſe reflections are very far from coming abroad in the order of time, wherein they were ſet down; but in that caſual order, wherein, when I was engaged to tack them together, I was able to light on them among my looſe and forgotten papers. Many of which being diſcovered to have been loſt, when ſome of the reſt were to be at the preſs; I was fain, for the compleating of the number, to inſert here and there ſome of a much freſher date, among thoſe that were made (as ſome know, who then read them) ſixteen or ſeventeen years ago, when my ſtyle could hardly be other than differing enough from what it now is.

And laſtly, that the differing natures of ſeveral ſubjects required, that the reflections on ſome of them ſhould be far longer than others. And as my want of leiſure, and ſometimes of diſpoſedneſs to write, induced me to make ſome of my conſiderations but ſhort; ſo I thought fit to let them paſs for their ſakes, to whom, for want of time or ſkill, the brevity of thoſe may make them the fitter, and the more recommend them.

Besides what has been alledged againſt the ſtyle, I know it may be objected, that in ſome of the meditations the ſubjects are very mean, and trivial; and that ſuch themes are not worthy the being deſcanted on. And indeed, if I aimed at the writer's advantage, more than the reader's, I could eaſily have left them out, and have ſubſtituted in their places ſome others, that lie by me, leſs liable to contempt. But I confeſs, I did not think my ſelf obliged to publiſh no meditations, but the leaſt cenſurable ones that I had made; and divers of thoſe intimated in the objection were purpoſely inſerted, when I was prevailed with to bundle up theſe looſe ſticks into faggots. For then, deſigning this treatiſe for the benefit of the generality of devout readers, I thought it not amiſs, amongſt divers reflections, (ſuch as moſt of the ſecond, and of the fourth ſections) more ſuited to thoſe peruſers that are either of the more intelligent ſort, or good proficients already, to inſert ſome few meditations, of a more familiar ſort, and eaſier to be lighted on; to keep thoſe from being diſcouraged from trying to make occaſional reflections, who may chance to have either barrenner fancies, or more unpractiſed pens, than even I had then. And thoſe (perhaps) who,

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who, without ſuch eaſily imitable examples, would not be invited to make occaſional meditations, may, by the practice of compoſing them, grow ſuch proficients in the art, as to ſurpaſs ſome, that deſpiſe ſuch humble beginnings.

But as I ſend abroad theſe papers without the author's name, that I may have the greater opportunity to hear other men's opinions of them, and the leſs temptation to wave the complying with thoſe that ſhall ſeem reaſonable; ſo if I ſhall find, that ſuch readers, as I eſteem competent judges in an affair of this nature, ſhall think, that thoſe reflections, wherein I have complied with the weaker ſort of peruſers, may be better ſpared, than I inſerted; I can eaſily repair that fault in the next edition, (if theſe trifles ſhall be thought worthy of another.) In the mean time, I preſume, that thoſe devout readers, who may be concerned in this matter, will take it kindly, that I have, for their ſakes, adventured to treat of ſubjects too mean and barren to furniſh me with almoſt any thing conſiderable, ſave the opportunities of manifeſting, how low I can ſtoop to gratify ſuch perſons.

I Know it is a new thing, that I have ventured to put ſome occaſional reflections into dialogues. But the reader will be leſs ſtartled at my deviating in this, and other things, from biſhop *Hall*'s way of writing occaſional meditations, if I acknowledge, that not to prepoſſeſs or biaſs my fancy, I purpoſely (till of late) forbad my ſelf the peruſing of that eloquent prelate's devout reflections. Which intimation being premiſed, I ſhall ſubjoin, that when I wrote for my own divertiſement, I ſometimes took pleaſure to imagine two or three of my friends to be preſent with me at the occaſion, that ſet my thoughts on work, and to make them diſcourſe, as I fancied perſons, of their breeding and tempers, would talk to one another on ſuch an occaſion. And one of theſe, whom I call *Euſebius*, being a Doctor of divinity; two others (*Eugenius* and *Genorio*) being travellers and fine gentlemen; and the fourth, (whom I name *Lindamor*) being a learned youth, both well born and well bred; I was apt to think, that ſome of their conferences might be allowed to paſs among the other papers; both becauſe novelty, and variety, are wont to be not unwelcome things, and becauſe this way of writing allows a ſcope for diverſity of opinions, for debates, and for replies, which moſt commonly would be improper, where only a ſingle ſpeaker is introduced. Not to add, that poſſibly if this way of writing ſhall be liked and practiſed by ſome famed and happier pen, that were able to credit and improve it; it may afford uſeful patterns of an inſtructive and not unpleaſant converſation: and ſuch reflections, being of the nature of ſhort and occaſional eſſays, may afford men the opportunities of ſaying the handſomeſt things they know, on ſeveral ſubjects, without ſaying any thing elſe of them, or filling above a ſheet, or perhaps a ſide of paper at a time. And the liberty, that this way of introducing ſpeakers allows, brings with it a conveniency, which it is more eaſy for an intelligent reader to conjecture at, than it were diſcreet for the writer to mention expreſly.

Another novelty will probably be taken notice of in the following papers, where the ſecond and fourth ſections, though by far the longeſt in the whole book, are intirely taken up; the former only by meditations on accidents relating to an ague that once afflicted me; and the latter by thoſe, that occurred to ſome anglers by the river ſide. But for this matter, I preſume, it will not be difficult to apologize. For having obſerved men to be inclinable, either openly to object, or at leaſt tacitly to ſuſpect, that in occaſional meditations, that may hold true, which is (perchance not altogether undeſervedly) ſaid of epigrams, that in moſt of them the conceits were not ſuggeſted by the ſubjects, but ſubjects were pretended, to which the conceits might be accommodated; I thought, that to manifeſt, that (at leaſt, ſome) writers of this kind of compoſures need not have recourſe to the ſuſpected artifice, the fitteſt way I could take was, by putting together, what the accidents of my ague, and of my angling journey, had ſuggeſted to me, to ſhew, that it is very poſſible for a perſon, that pretends not to a very pregnant fancy, to diſcourſe by way of reflection upon the ſeveral circumſtances, that ſhall happen to occur to his conſideration, though one ſubject ſhould require above fifteen differing meditations, and the other above twenty. Not to add, that it was rather wearineſs and deſign, than want of thoughts upon other paſſages relating to the ſame ſubjects, that kept me from increaſing the number of thoſe reflections.

As for the ſimilitude, though ſome would make me hope, that they will be at leaſt excuſed; and though it were perhaps no great vanity for one, that does aſſiduouſly enough converſe with the works of nature and the productions of art, to think he has the means of furniſhing himſelf with pretty ſtore and variety of compariſons: yet for all this, I am not willing to quit my pretenſions to a ſhare in the wonted effects of that common equity, which forbids to exact too accurate a likeneſs in the making of compariſons, which orators confeſs ought to be judged with indulgence, and without exacting a conformity in other attributes betwixt the things compared, provided there be a competent likeneſs in reference to the particular, wherein the collation or parallel is made.

And if I have, on ſome occaſions, proſecuted the reſemblance through all the particularities, wherein the parallel could be made to hold, more fully and nicely than is uſual in ordinary compariſons; and if in ſo doing I may have at any time a little ſtrained the ſimilitude, the better to accommodate it to my preſent theme, and deſign; I have this to repreſent, that to diſplay reſemblances to the full, and inſiſt on their particular circumſtances, is oftentimes no more than the nature of theſe compoſures does allow, if not require; and that, on ſuch occaſions, to ſtretch the parallel

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as far as it can well be made to reach, is but a venial fault, which many readers are diſpoſed not only to pardon, but to like. As if, in ſome caſes, it fared with ſimilitudes as with bows, which they though they may be bent ſo forcibly, as to be thereby broken or ſpoiled; yet by being ſtrained ſomewhat more than ordinarily, they acquire a greater ſtrength, and enable the arrow to pierce farther, and to make a ſmarter impreſſion, than elſe it would.

THE protaſis (as rhetoricians call the firſt part of a compariſon) may in ſome of the following reflections appear to be too much amplified, and needleſly to lengthen the meditation. But not to urge, that ſometimes the more conſpicuous adjuncts of the ſubject were ſo mean and barren, that there was a kind of neceſſity to exaggerate, or to expatiate upon little circumſtances to invite attention; the protaſis, wherein we diſplay and conſider the minute particularities of the theme, being the ground-work of all the reſt, and it being far more eaſy to ſay little, than much, with equal pertinency upon a ſubject; I thought it not amiſs, to afford unpractiſed readers the moſt aſſiſtance of examples in ſuch caſes, wherein it is probable they will moſt need it; eſpecially ſince he, that has accuſtomed himſelf to write copiouſly, may eaſily contract his diſcourſe when he will, by omitting as many paſſages as he pleaſes; and it is far more difficult for a beginner to ſupply barrenneſs, than retrench ſuperfluities. Which are not always ſuch faults, but that I remember ſome great maſters in the art of oratory have pronounced redundancy to be a good ſign in a young writer, as taking it for a mark of a fruitful and exuberant fancy, that, in its productions, there is ſomething to be cut off. So that if there ſhould be found any luxuriant expreſſions in ſome of thoſe thoughts, that were written down, when I had not yet attained my 19th or 20th year, when I might be allowed to write not always to employ, but ſometimes to amuſe my ſelf; I may hope, that the ſame youth, that was my temptation to write them, may prove my excuſe for having written them, as it may for leaving them unexpunged; that as I deſire to invite as well young gentlemen as other readers, to pen occaſional meditations, ſo I find, that ſome of the readers, I am willing to pleaſure, do as little diſlike that luxuriant way of writing now, as I did then: as youths and ladies oftentimes better reliſh muſt than wine.

I KNOW too, that there may be found, in ſome of thoſe protaſes, divers paſſages, and particularly ſome deſcriptions (that often make a great part of them) which to ſome readers will not ſeem noble and gaudy enough. But to ſuch peruſers it may be repreſented, that a ſuitableneſs to the theme, how mean ſoever it be, may very well, as a piece of decorum, be allowed to a writer, and in few caſes more than in point of deſcriptions; and that theſe being but pictures drawn (with words inſtead of colours) for the imagination, the ſkilful will approve thoſe moſt, that produce in the mind, not the fineſt ideas, but the likeſt; as a critick in limning will more prize the picture of an old meagre Sibyl, where the wrinkles and the ſallow ſkin are drawn exactly to the life, than a dozen ordinary pictures of the ſpring, (which yet are wont to charm vulgar eyes) though the youthful face, which repreſents that florid ſeaſon, have as gaudy colours upon the cheeks and lips, as imbelliſh the roſes and lilies, which compoſe the chaplet that adorns the head.

AND poſſibly there will be found other readers (and thoſe too ſkilled in rhetorick) that will accuſe ſome other of our meditations, as being too elaborate, or too pompous, for the themes, whereunto they are accommodated. But having laid by a competent number of thoſe lately mentioned reflections, wherein I aimed chiefly at inviting and aſſiſting readers of meaner capacity; I confeſs, that in the other meditations, aiming either at my own divertiſement, or the gratifying another ſort of perſons, I allowed my ſelf to make choice of ſuch applications of the objects I conſidered, as I thought every body would not ſo eaſily light on. And, provided the reflections were not ſtrained, nor too far fetched, I thought it not amiſs they ſhould be ſomewhat ſurpriſing; that I might by the way of handling the ſubjects I was to treat of, ingage an attention, which otherwiſe I could ſcarce expect for ſuch unpromiſing themes. I know, that if the judgment of ſome ſevere criticks were as infallible as themſelves think it, the ſtyle of ſome of the following reflections would ſeem diſproportionate to ſuch mean and trifling ſubjects. I do not perhaps ignore what rhetoricians are wont to teach, of what they call the three differing characters of writing; I have read thoſe diſcourſes, that *Cornificius* propoſes as the patterns of the ſublime, the moderate, and the humble way of expreſſing one's ſelf on differing occaſions; and I have been taught, and willingly acknowledge, that all themes are not ſo well capable of that character, which they call ſublime; and that, according to the nature and dignity of the ſubjects that one treats of, the manner of handling them ought to be varied. But if I were much concerned in this matter, I might reply, that notwithſtanding all this, I know, that even the artiſts themſelves do not ſo perfectly agree about the defining of theſe matters; and the grand rule about theſe characters being only, that the laws of decorum (or, as the French call it *bien-ſeance*) be not violated, in the eſtimate of that decorum, I ſee no great reaſon to confine my ſelf to the magiſterial dictates of either ancient or ſcholaſtick writers. For, living in this age, and in this part of the world, where we are not like to have thoſe for readers, that died before we were born, I ſee not why one may not judge of decorum by the examples and practices of thoſe authors of our own times and countries, whoſe writings are generally eſteemed by judicious men.

AND certainly, in the judging of what is decent on particular occaſions, we muſt as well conſider, who it is that is introduced as the ſpeaker, as what it is he ſpeaks of. And

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though it be improper to do what thoſe have done, that have unadviſedly made ſhepherds and nymphs diſcourſe like philoſophers or doctors of divinity; yet when the writer either ſpeaks himſelf, or introduces any, whom he repreſents as intelligent perſons; they may be allowed, even about things ordinary and mean, to talk like themſelves, and employ expreſſions that are neither mean, nor ordinary. As *Virgil*, in his admired Georgicks, does in ſome paſſages, where he treats of contemptible inſects, ſpeak of them in ſo noble and lofty a ſtrain, that when he mentions multitudes of ants, one would think he were ſpeaking of an army of Moors; and when he gives an account of bees, his expreſſions about their common-wealth would ſcarce miſbecome the majeſty of that *Rome*. Such paſſages do, notwithſtanding the great diſparity of themes, make the ſtyle of his Georgicks as well noble (if not ſtrictly heorick) as that of his Æneids; and when he writes of ants and flies, he does it in a ſtrain worthy of the ſame pen, that ſo loftily deſcribes the deſtruction of *Troy*, and the adventures of that hero, whom he would have to be (thought not immediately) the founder of *Rome*.

It nigrum campis agmen.

I WILL not ſay, that ſince there is a mode in language as well as in clothes, I ſee not, why the faſhion, that now-a-days allows our gallants to wear fine laces upon canvaſs and buckram, might not warrant the tricking up of ſlight ſubjects, with the richer ornaments of language: nor will I examine, whether men may not except againſt the authority of ſome jejune writers, that taking upon them to preſcribe the laws of ſtyle, make ſo many of their precepts negative, that one may ſuſpect them indited not ſo much by ſkill, as envy; which makes ſuch aſſuming law-givers miſtake the impotence of a barren fancy for the ſkilfulneſs of a critical judgment, and (valuing only the ideas they think they can reach) condemn whatever they deſpair to imitate. And, from thoſe, that would be thought to cenſure the moderns, but out of a veneration for the ancients, one might, methinks, reaſonably expect but light cenſures for employing upon occaſion that noble figure of rhetorick called hyperbole; ſince I ſhould be loth to uſe it often, with no more reſerve, than thoſe great orators, *Tully* and *Iſocrates*, have ſometimes done before me. But a juſt debate of the rules of eſtimating the decency would take up ſo much room, as muſt make it improper for this place; where all I contend for is, that though when one treats of various ſubjects, ſomewhat differing ſtyles are indeed to be accommodated to them; yet this is to be ſo done, as ſtill to preſerve a certain dignity in expreſſions. So that a writer may be ſometimes engaged by his ſubject to uſe a lofty ſtyle, but without ever being obliged to employ an abject one; though indeed in ſome caſes he may be allowed to ſtoop below what he is bound to, and forbear ſoaring, as well as avoid creeping. Nor am I, for my own part, much concerned to inſiſt here on the ſubject I juſt now declined to debate. For if I miſ-remember not, *Cicero* himſelf, as well as ſome ſucceeding orators, allow in diverſ caſes to ſhift characters, even in the ſame diſcourſe, according to the differing particulars, that happen to fall under conſideration; and ſome of them add this reaſon, that hence there will ariſe variety, which is wont to be a welcome thing. And to apply this to the occaſional reflections, that may be concerned in this debate, I muſt deſire the reader to take notice of theſe two things: the one, that though the thing it ſelf, which ſets a man's thoughts at work, may be but mean in other regards, yet that, which the reflector pitches upon to conſider, may be of another nature; as though the glow-worm, which afforded me the IVth. reflection of the Vth ſection, be but a ſmall and contemptible inſect, yet the light, which ſhines in his tail, and which makes the chief theme of the meditation, is a noble and heavenly quality, and might have juſtified the having many things ſaid of it, for which the ſublime character would have been the moſt proper. The other particular I meant to point at, is, that oftentimes, when the protaſis, or former part of a reflection, is ſpent upon conſidering ſome mean and trivial ſubject, the apodoſis, or reddition, contains ſuch an application of what one was taking notice of in the ſubject, that the thing pointed at may be ſome important moral inſtruction, or perhaps ſome theological myſtery; and conſequently may require and juſtify another than the former humble ſtyle, and admit all the quickneſs of expreſſion and the richeſt ornaments, that belong to thoſe two higher characters, which rhetoricians call the ſubtil, and the magnificent. But if I ſhould now and then deviate from bounds, which, not being conſpicuous, it is difficult never to ſwerve from, I have this peculiar apology to make for ſuch aberrations; that writing for the moſt part of themes wholly new, and untreated of by others, I muſt needs want the aſſiſtance of examples to regulate or authorize my expreſſions; about which I need not be yet very ſollicitous, if I may truſt a learned and applauded writer (whoſe cenſure I deſired) that is both able to judge ſkilfully, and wont to judge freely.

THESE things I have the more carefully inſiſted on, becauſe I would not have thoſe ingenious perſons, that may chance to caſt their eyes on theſe papers, to be tempted by any imperfections of mine, to think otherwiſe of occaſional meditations, than that though there be ſome, yet there are not very many, of their themes ſo low and contemptible, but they are capable of affording reflections of another nature to them, that are dextrous in making application of things. And I would not have ſuch diſcouraged from hoping to find in many themes, that ſeem deſpicable at firſt ſight, ſome hint or other, that may give thoſe, that have wit or eloquence, opportunity enough to diſplay thoſe qualities. For as there is a great difference betwixt ſuch writers, and common ones; ſo it is very material by what pens the ſubject is treated of; and extraordinary perſons, in eſtimating what they are like to perform, muſt not only conſider the unpromiſing nature of their ſubject, but the activity

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vity of their own fancy, and the pregnancy of their own wit. For though the ſtars cannot, the luminaries can, clothe the light and wandering vapours of the air with the colour of gold, and of roſes; and the ſun, by his piercing and improving beams, cannot only make diamonds ſparkle, and rubies flame, but by his action upon an obſcure cloud can make even that exhibit all thoſe glorious and charming colours, for which we admire the rainbow.

And, that the following papers may prove to ſuch perſons the leſſer temptations to undervalue and miſ-judge of this kind of compoſures; I am firſt to advertiſe the reader, that they are capable of ſo much greater variety, than the following treatiſe preſents, that beſides the vaſt multitudes of particulars unmentioned in it, that may be added under thoſe heads, to which the enſuing meditations are referred, there are ſeveral diſtinct ſorts or kinds of occaſional thoughts, (ſuch as thoſe, that are made upon texts of ſcripture, or relate to leſs familiar points of divinity, or other learning, or contain hiſtorical applications, *&c.*) upon which I have, out of haſte, and other reaſons, purpoſely forborn (though not to write, yet) to publiſh reflections. And in the next place, I muſt here frankly acknowledge, that many of the enſuing reflections are ſo far from being the beſt, that even no better a pen than mine could make, that they are much inferior to divers, that I have already made; though (for allowable conſiderations) I have forborn to publiſh them. And I muſt confeſs, that I am more beholden to my occaſional reflections, than they are to me. For, whereas they have furniſhed me with divers of the thoughts, which have been the favourableſt entertained by the readers of my other books of devotion; I did much impoveriſh theſe papers, that profeſſedly contain my occaſional reflections, by not only leaving, but taking out of them ſeveral things, which were the moſt likely to have recommended them; that I might accommodate other writings, for which I had a greater kindneſs or concern.

As for the *Diſcourſe of Occaſional Reflections*, all that I ſhall ſay of it, is, that conſidering how early I attempted that ſubject, and that I was fain to repair, as well as I could, the unſeaſonable miſs of divers papers belonging to it, when I diſpatched it to the preſs; conſidering theſe things (I ſay) I deſpair not, but that it will be thought, that I have not ſaid nothing in favour of a ſubject that hitherto had ſo little ſaid to recommend it, that even the eloquent Biſhop *Hall* *, employing but ſome lines, not pages, upon the praiſe and utility of it, (which he mentions but in very general terms) left me to find out, by my own thoughts and experience, the various conſiderations, by which I have endeavoured to diſplay the uſefulneſs of the way of thinking I would invite to. Which I have further manifeſted, by applying to that ſcope divers paſſages of ſcripture, (which the reader muſt therefore not wonder, if he do not now meet with) as texts, that either by way of example, or upon other accounts, belong to what I have written about the method of making occaſional reflections.

* *In the latter part of his proeme, whereof the whole amounts not to one page of this preface.*

It is true, the diſcourſe may ſeem ſomewhat incompleat, becauſe of the omiſſion of this way, that is more than once mentioned in it.

But though the looſe papers, wherein that method, and divers examples of it, are ſet down, were lying by me, when I tacked up thoſe that now come abroad; yet my occaſions eaſily prevailed with me to continue to ſuppreſs them. For though I did not much ſcruple to comply with my haſte, and avocations, by forbearing to ſwell a book, whoſe bulk already much exceeded my intention; becauſe that, as the papers, that now appear, were extorted from me, ſo I confeſs, that I was not fond of expoſing thoſe, that I had an expedient to keep back: but that I think it very fit to obſerve, firſt, whether the reception, that the following meditations will find, will make me and others think it worth while to have the ways publiſhed, that I was wont to uſe in making them.

I had almoſt forgot to intimate, that ſome urgent avocations having obliged me to ſend the following treatiſe to the preſs without reading it over my ſelf, I now find, that my haſte will make me need an apology to thoſe readers, that expect to have the paſſages and phraſes of ſcripture printed in a diſcriminating letter, and quoted in the margin. For though in books of poſitive, or of controverſial divinity, I confeſs I have often obſerved a margin, ſtuffed with a multitude of citations, to contain divers ſo unconcluding, if not impertinent, that the number does better ſhew the author's memory than his judgment; yet in books of devotion, I am not much averſe from complying with the generality of readers, who expect to be informed by the margin, where they may find thoſe ſtories, and expreſſions, which their being borrowed from an inſpired book, make more operative and emphatical. But I muſt on this occaſion further intimate, that as to thoſe citations of paſſages of ſcripture, wherein I may ſeem to have miſ-recited the words of the text; though as to ſome of them, that were ſet down when I had not a bible or concordance at hand, my memory may have deceived me as to the words (which is no more than has often happened to the fathers themſelves in the like caſe, and is a venial fault, where dogmatical or polemical divinity are not concerned) yet oftentimes my variations from the Engliſh verſion were made on purpoſe. For having had the curioſity to get my ſelf inſtructed, as well by Jews as Chriſtians, in the eaſtern tongues (eſpecially the Hebrew,) I thought I need not ſtrictly confine my ſelf to the words of our tranſlators, whenever I could render the meaning of a text in ſuch terms as to me ſeemed proper or expreſſive; or, without injuring the ſenſe of the Hebrew or the Greek, could better accommodate my preſent purpoſe.

Now whereas ſome may think, that in this preface I employ excuſes, that ſeem (ſome of them) not to agree with one another; I deſire it may be conſidered, that the meditations they relate to, being not only written upon differing ſubjects, but (which is more) deſigned for

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for very differing uſes (ſome of thoſe diſcourſes being intended to invite the more unſkilful, and encourage the more deſpondent ſort of readers, and others, to entertain proficients) it was but requiſite, that I ſhould, by every differing (and, perchance, ſeemingly repugnant) conſiderations, give an account of ſuch differing ways of writing them, as ſuch diſtant ſubjects, and my ſcope, required.

But what if it ſhould fare with me now, as it has done on other occaſions, on which my friends have accuſed me, of framing more objections againſt my ſelf, than were afterwards made againſt me by my readers? I dare not ſay it is impoſſible, but that this may prove the caſe. But if it do ſo, I ſhall not yet think my ſelf to have altogether miſſed my aim in what I have hitherto repreſented. For I have mentioned the more particulars, and diſcourſed the more largely of them, that if they prove not needful apologies for my reflections, they may prove uſeful conſiderations for thoſe, whom I would invite to exerciſe their pens in ſome ſuch way of writing; divers of whom will probably be encouraged to venture upon making ſuch compoſures, when they find excuſes for divers of thoſe things, that are the moſt likely to be thought to blemiſh ſuch eſſays, (or diſhearten beginners from attempting them) to be drawn up already to their hands. But as for my own particular, if I could make none of the apologies now inſiſted on for the imperfections imputable to this treatiſe; yet I ſhould not be deſtitute of a very juſt excuſe for the publication of it. For divers devout perſons, that had more partiality for theſe writings, and leſs tenderneſs of my reputation, than I could have wiſhed, having long ſollicited the publication of thoſe they had in their hands, were at length ſo reſolved to effect it, that, in ſpite of the promiſes I at length made them to comply with their deſires, when ſome other writings I was then about ſhould be diſpatched; I was fain to make uſe of a legal artifice to hinder for a while at the Stationers hall the publication of divers papers, that I had not ſo much as read over.

But I confeſs I take notice of theſe paſſages, rather to excuſe thoſe imperfections, which haſte may have occaſioned in theſe immature productions, than to apologize for writing on ſuch a ſubject. For ſo many advantages, that may accrue to a devout and ſkilful perſon, by aſſiduouſly making of occaſional meditations, have been diſplayed in the diſcourſe, that is premiſed to thoſe that follow; that I hope the former part of this book will ſufficiently apologize for my having written the latter; eſpecially if to the other particulars propoſed in the newly named diſcourſe, as things fit to recommend that kind of thoughts, I here be allowed to add, that a man's devotion may not alone be cheriſhed by occaſional meditations, upon the account of thoſe, which every private Chriſtian makes for himſelf, but by the help alſo of thoſe, which he finds made by others, or intends for them. For not only whilſt pious reflections are making, they are proper to inſtruct the mind, and warm the affections; but the objects, upon which ſuch meditations have been made already, either by our ſelves or others, do revive the memory of thoſe good thoughts that were ſuggeſted by them. So that when diligence and proficiency in the practice of our Meleteticks ſhall have ſupplied us with religious, and handſome reflections, upon the moſt obvious works of nature, and the moſt familiar occurrences of human life, devout perſons will have the advantage to live almoſt ſurrounded either with inſtructors, or remembrancers. And when they want ſkill, or are indiſpoſed to extract ſpiritual things out of earthly ones, they may, without racking their invention, be furniſhed with good thoughts, upon many objects, by their memory. For (as I elſewhere more fully declare,) thoſe truths and notions, that are dreſſed up in apt ſimilitudes, pertinently applied, are wont to make durable impreſſions on that faculty; inſomuch that though I am far from pretending any of the reflections to be met with in the following treatiſe, to be made of that nature; yet ſuch as they are, divers conſiderable perſons of differing ages and ſexes have been pleaſed to ſay (which is an advantage may richly recompenſe more trouble than thoſe writings coſt me) that they ſcarce ever ſee ſuch or ſuch particular things, on which I have written reflections, without remembering both thoſe thoughts, and their author. So that they, who have ſo eaſily attainable things, as happier pens than mine, in ſetting down occaſional meditations, may have the ſatisfaction of making almoſt the whole world a great * *Conclave Mnemonicum*, and a well furniſhed *Promptuary*, for the ſervice of piety and virtue, and may almoſt under every creature and occurrence lay an ambuſcade againſt ſin and idleneſs.

Would we but keep our wholeſome noritons together, mankind would be too rich. *Bp.* Hall *in his Proëme.*

* *So they call a certain room, artificially furniſhed with pictures, or other images of things, whereby to help the memory.*

Nor is this indirect way of inſtructing men, unlawful for a Chriſtian, or unworthy of him. For in the ſpiritual warfare, where our adverſary is the old ſerpent, ſtratagems are as lawful as expedient; and he that gets the victory, whether or no he wins reputation by the manner, is ſure to obtain (a greater recompenſe) glory, by the ſucceſs. A teacher is not obliged to imitate *Alexander*, who, upon a diſputable punctilio of gallantry, that was neither wiſe nor charitable, refuſed to ſteal a victory. For the prophet *Nathan* ſcrupled not to deceive *David*, that he might reclaim him, and ſurprize him into a confeſſion of the criminouſneſs of his fault. And the Apoſtles being termed by their maſter, *fiſhers of men*, were warranted to make uſe of baits, as well as hooks, and nets. And our Saviour himſelf, by the parable of the wicked huſbandman, that uſurped the vine, drew the Phariſees to an acknowledgment, which they ſtarted from as ſoon as they perceived what they had done. And the ſame divine teacher did ſo frequently imploy fictions to teach truths, that to condemn figurative and indirect ways of conveying even ſerious and ſacred matters, is to forget, how often Chriſt himſelf made uſe of parables. And I am the leſs troubled to ſee ſome thoughts of mine, which, though unpoliſhed, have a natural tendency to inveigle men (if I may ſo ſpeak)

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into piety and virtue, thruſt abroad into the world; not only becauſe I ſee no reaſon to deſpair, that even as to the moſt obnoxious of theſe meditations, the examples they afford may make them uſeful, when the things they contain do not make them conſiderable and equitable, readers will rather pity, than admire to find, that an author does not ſoar, whilſt he is clogged or depreſſed by the meanneſs of his ſubject. But becauſe ſome experience ſeems to promiſe, that their novelty and variety will procure the book in general a favourable entertainment; and, indeed, if I had written in a more uſual or a more ſolemn way, I ſhould, perchance, have had no readers but divines, or humaniſts, or devout perſons, or deſpiſers of the world, or (in a word) the maſters, or lovers of that one kind of learning, to which my ſubject did belong: but treating, as I do, of whatever chanced to come in my way, and conſequently of many very differing and unuſual things, curioſity will probably invite both the learned and the devout; both gentlemen and ladies; and, in a word, inquiſitive perſons of ſeveral kinds and conditions, to caſt their eyes upon theſe reflections; which, by their variety and ſhortneſs, will have this advantage, towards the making them entertained with patience, that ſcarce any of them will give him, that peruſes them, above half a quarter of an hour's exerciſe of it.

And as I thought it not any fault to have a regard to what was like to pleaſe a good part of the readers I wrote for, (though it would not elſe perhaps have pleaſed me, any more than it will the nicer palates of the criticks;) ſo if theſe trifles chance to meet with half ſo kind a reception from the publick, as they have had from particular perſons, I ſhall not, perhaps, want the conſolation, which may be derived from the judgment of a great maſter of wit, who ſcrupled not to affirm, that he had rather his entertainments ſhould pleaſe the gueſts, than the cooks. Though they, that would compleat the good fortune of theſe papers, may do it more effectually, by addicting themſelves (as conſiderable perſons have been of late induced to do) to write occaſional reflections (how excellent ſoever they may prove) than by being kind to theſe; ſince having written them, not to get reputation, but company, I cannot but be unwilling to travel alone; and had rather be out-gone than not at all followed, and ſurpaſſed than not imitated.

DISCOURSE

TOUCHING

Occaſional Meditations.

SECT. I.

CHAP. I.

THE way of thinking, whoſe productions begin to be known by the name of Occaſional Meditations, is, if rightly practiſed, ſo advantageous, and ſo delightful, that it is pity the greateſt part, even of ſerious and devout perſons, ſhould be ſo acquainted with it: and therefore, dear ſiſter, your deſire to bring this way of meditation into requeſt with ſome of our friends is that, which I cannot diſapprove. But I am ſo far from having the vanity to think, that the trifles of this kind, your commands make me trouble you with, would recommend occaſional reflections to thoſe, whoſe eyes they were not meant for, that I think my ſelf obliged to premiſe ſomething touching the uſefulneſs of this way of meditating, leſt the careleſs and unpoliſhed inſtances you will, I fear, meet with, among thoſe I now preſent you, ſhould diſparage and bring a prejudice upon compoſures of this kind in general: wherefore, judging it requiſite, to premiſe ſomething touching this way of thinking, I ſhall forthwith apply my ſelf to that taſk. And I ſhould judge it a very natural diſtribution to divide the following diſcourſe into two parts; the firſt of which ſhould contain ſome invitations to the cultivating this ſort of meditations, and the latter ſhould offer ſomething by way of method, towards the better framing of them. But leſt I ſhould at this time be hindered from treating of each of them diſtinctly, I will at preſent omit that diviſion, and endeavour in recompenſe ſo to deliver the motives I am to propoſe, that the firſt part of the diſcourſe may not appear maimed, though it be unattended by the ſecond; and yet the particulars that might compoſe the ſecond, may (if it prove convenient to mention them at this time) be commodiouſly enough inſerted in opportune places of the firſt.

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OF inducements to this exercise, I might perhaps name many; but, for order's sake, I shall comprize them in the ensuing five; the first whereof will take up the present section, and the remaining four, as many others.

CHAP II.

AND first, the way of meditating, I would recommend, conduces to keep the soul from idleness, and employments worse than idleness; for while a man's thoughts are busied about the present subjects of his reflections, our ghostly adversary is discouraged to attempt that soul, which he sees already taken up with something, that is at least innocent, if not good. If I had not elsewhere displayed the evil and danger of idleness, and represented it as a thing, which though we should admit not to be in it self a sin, yet may easily prove a greater mischief than a very great one, by at once tempting the tempter to tempt us, and exposing the empty soul, like an uninhabited place, to the next passion or temptation, that takes the opportunity to seize upon it: If (I say) I had not elsewhere discoursed at large against idleness, I might here represent it as so formidable an enemy, that it would appear alone a sufficient motive to welcome our way of meditation; that it banishes idleness. He that is versed in making reflections upon what occurs to him; he that (consequently) has the works of nature, and the actions of men, and almost every casualty, that falls under his notice, to set his thoughts on work, shall scarce want themes to employ them on: and he that can (as it were) make the world vocal, by furnishing every creature, and almost every occurrence, with a tongue to entertain him with, and can make the little accidents of his life, and the very flowers of his garden, read him lectures of ethicks or divinity; such a one, I say, shall scarce need to fly to the tavern, or a worse place to get a drawer, or gamester (perhaps no better qualified) to help him to get rid of his time: such a one will rather pity, than pursue those, who think it their privilege to spend their whole life in diversions from the main business of it; and out of an unskilful, and ill-governed self-love, are come to that pass, that they cannot endure to be with themselves. Such a one will not need to frequent the company of those gamesters, that are sure to lose that, which all their winnings will never be able to buy, or to redeem; and expose themselves coldly to as many casualties, as even war could threaten; and voluntarily tempt those passions it is the task of wisdom to decline, and a virtue to suppress; losing nothing but their time, without losing their patience too, and commonly a great part of that reverence and submission they owe to him, of whom the scripture tells us, that even *of lots themselves, the whole disposal is his.* Nor will he need, for want of knowing what to do when he is alone, to make it his almost daily employment, to make impertinent visits to unsanctified companies, where sometimes he he may lose his good name, often his innocence, oftner his zeal, and always his time.

Prov. xvi. 33.

AND as the exercise, I would persuade, will help to keep us from idleness; so will it, to preserve us from from harbouring evil thoughts, which there is no such way to keep out of the soul, as to keep her taken up with good ones; as husbandmen, to rid a piece of rank land of weeds, do often find it as effectual a course to sow it with good seed, as to cut them down, or burn them up. And indeed, the thoughts of many a person, are oftentimes so active, and restless, that something or other they must, and will perpetually be doing; and like unruly soldiers, if you have not a care to imploy them well, they will employ themselves ill.

WHEREFORE, when a man hath once rendered this way of thinking familiar, sometimes the subject of his meditation will lead him to thoughts, and excite affections, full of serenity, and joy, like those fair mornings, where the cloudless beams, and cherishing warmth of the sun, inviting the lark to aspire towards heaven, make her at once mount and sing; and when the mind is raised to such a welcome and elevated state, to listen to an ordinary temptation, a man must forgo his pleasure, as well as violate his duty, and in the difference betwixt the imployment that busies him, and that whereto he is sollicited to stoop, he will easily discern, that his innocence will not be the only thing, that he would lose by so disadvantageous a change; and sometimes too, whether or no the imployment, that busies his thoughts, happen to be so delightful, it will however appear to be so considerable, that it will seasonably furnish him with that excellent answer of *Nehemiah* to those, that would have diverted him from building of the temple, to come to a treaty with them, *I am doing a great work,* (and such indeed is the serving God, and the improving the mind, whether we consider its importance, or its difficulty) *so that I cannot come down: why should the work cease, whilst I leave it, and come down to you?* Which last expression suits very well with the present case; since, when a pious soul is once got upon the wing of contemplation, she must descend and stoop to exchange her converse with heavenly objects, for one with earthly vanities; and much more must she debase and degrade herself, if the things she is tempted to, be lusts, which she will thence clearly discern, to be as low as the hell they belong to, and deserve.

Nehem. vi. 3.

AND as these objects will afford employment enough to our reflector, so will the wholesome instructions they will suggest, incline him to shun those ways of wasting his time, which they enable him easily to avoid. For I have observed this difference, betwixt ghostly dangers, and ordinary ones, whereas in military hazards, those, that are the most forward to thrust themselves into dangers, are commonly the best able to surmount them; they, on the contrary, are wont to be the most fearful of temptations, that are the most resolved, and best qualified to resist them.

CHAP.

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CHAP. III.

NOR will the Meleteticks (or way, and kind of meditation) I would perſuade, keep men alone from ſuch groſs and notorious idleneſs; they may be aſked the queſtion, propoſed by the houſholder in the goſpel, *Why ſit ye here all the day idle?* But this way of thinking may in part keep men from the loſs of ſuch ſmaller parcels of time, as though a meer moraliſt would perhaps cenſure the neglect of them in others, yet a devout perſon would condemn it in himſelf; for betwixt the more ſtated employments, and important occurrences of human life, there uſually happen to be interpoſed certain intervals of time, which, though they are wont to be neglected, as being ſingly, or within the compaſs of one day, inconſiderable; yet in a man's whole life, they may amount to no contemptible portion of it. Now theſe uncertain parentheſes, (if I may ſo call them) or interludes, that happen to come between the more ſolemn paſſages (whether buſineſſes, or recreations) of human life, are wont to be loſt by moſt men, for want of a value for them, and even by good men, for want of ſkill to preſerve them: for though they do not properly deſpiſe them, yet they neglect, or loſe them, for want of knowing how to reſcue them, or what to do with them. But as though grains of ſand and aſhes be a part; but of a deſpicable ſmallneſs, and very eaſy, and liable to be ſcattered, and blown away; yet the ſkilful artificer, by a vehement fire, brings numbers of theſe to afford him that noble ſubſtance, glaſs, by whoſe help we may both ſee our ſelves, and our blemiſhes, lively repreſented, (as in looking-glaſſes) and diſcern celeſtial objects, (as with teleſcopes) and with the ſun-beams, kindle diſpoſed materials, (as with burning-glaſſes:) ſo when theſe little fragments, or parcels of time, which, if not carefully looked to, would be diſſipated, and loſt, come to be managed by a ſkilful contemplator, and to be improved by the celeſtial fire of devotion, they may be ſo ordered, as to afford us both looking-glaſſes to dreſs our ſouls by, and perſpectives to diſcover heavenly wonders, and incentives to inflame our hearts with charity and zeal. And ſince goldſmiths and refiners are wont all the year long carefully to ſave the very ſweepings of their ſhops, becauſe they may contain in them ſome filings, or duſt of thoſe richer metals, gold and ſilver; I ſee not why a Chriſtian may not be careful, not to loſe the fragments and leſſer intervals of a thing incomparably more precious than any metal, time: eſpecially, when the improvement of them, by our Meleteticks, may not only redeem ſo many portions of our life, but turn them to pious uſes, and particularly to the great advantage of devotion.

Matth. xx. 6.

AND indeed, the affairs and cuſtoms of the world, the employments of our particular callings, the allowable recreations, that health, or wearineſs requires, and the multitude of unforeſeen, and ſcarce evitable avocations, that are wont to ſhare our time among them, leave us ſo little of it, to employ in the ſet and ſolemn exerciſes of devotion, and make thoſe ſo unfrequent, that our hearts are in great danger of being, by the buſineſs, and pleaſures, and hurry of the world, if not perverted from aſpiring to, at leaſt too long diverted from enjoying communion with God, and kept too much ſtrangers to him; if in the long intervals of our more ſolemn exerciſes of devotion, we be not careful to lay hold on the ſhort and tranſient opportunities of cheriſhing, and reviving that grace in us, and do not by the riſes given us by the things that occur, take occaſion to make frequent, though but ſhort flights heaven-wards, in extemporary reflections, ſerious ſoliloquies, piercing ejaculations, and other mental, either exerciſes, or expreſſions of devotion: by which means, we may make thoſe very objects, and occaſions, that would diſcourage, or at leaſt diſtract our minds, elevate and animate them; as *Jonathan* made thoſe very things, whereby his enemies, the Philiſtines, ſought to intrap, or deſtroy him, incouragements to fight with them, and omens of his victory over them. And as ſcarce any time is ſo ſhort, but that things ſo agile, and aſpiring, as the flames of a devout ſoul, may take flight to heaven, (as *Nehemiah* could find time to dart up a ſucceſsful prayer to the throne of grace, whilſt he ſtood waiting behind the king of *Perſia*'s chair) ſo by theſe extemporary reflections, as well as by other mental acts of piety duly made, a devout ſoul may not only reſcue theſe precious fragments of time, but procure eternity with them.

SECT. II.

CHAP. I.

A SECOND inducement to the practice of making occaſional meditations, is, that for an exerciſe of devotion, it is very delightful, and that upon ſundry accounts.

FOR firſt, variety is a thing ſo pleaſing to human nature, that there are many things, which it, either alone, or chiefly, recommends to us, and it is rarely ſeen, that we love the ſame things, very much, and very long; and of things that elſe would appear equally good, we uſually think that the better, which happens to be another. Now, a perſon addicted to make occaſional meditations may be ſupplied with ſubjects, whoſe variety is ſcarce imaginable: for the works of nature and of art are not the only objects, that often preſent themſelves to our reflector's conſideration; the revolutions of governments, the fates of kingdoms, the riſe and ruin of favourites; and, on the other ſide, the moſt ſlight and trivial occurrences; and in ſhort, all that he ſees happen from the higheſt tranſactions, to the ſlighteſt circumſtances, incident to human affairs, may afford matter of contemplation to a perſon diſpoſed to it. The mind of man is ſo comprehenſive, and ſo active a faculty, that it can force its paſſage into thoſe imaginary ſpaces, that are beyond the outermoſt part of the outermoſt heaven, and can in a moment return back, to conſider the ſmalleſt circumſtances of the meaneſt of human affairs; ſo that

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that the thinking faculty, being equally fit, and diſpoſed to reflect upon the works of God, and the actions of men, how unlikely is it, that it ſhould want variety of ſubjects to be employed on, whilſt the whole world makes but a part of its object; and the ſeveral productions of nature and art, of the providence of God, and the will of man, may be ſo many ways conſidered, and ſo variouſly compounded, that they may well be ſuppoſed capable of affording occaſions to notions and reflections far more numberleſs than themſelves; ſo that the moſt vigorous, and the moſt active ſoul, is in leſs danger of wanting freſh game, than thoughts to purſue ſuch endleſs variety of it.

BESIDES, whereas men are wont, for the moſt part, when they would ſtudy hard, to repair to their libraries, or to ſtationers ſhops; the occaſional reflecter has his library always with him, and his books lying always open before him, and the world it ſelf, and the actions of the men that live in it, and an almoſt infinite variety of other occurrences being capable of proving objects of his contemplation; he can turn his eyes no whither, where he may not perceive ſomewhat or other to ſuggeſt him a reflection.

BUT that, which may much indear ſuch meditations, is, their ſurprizing even him, whoſe thoughts they are: For one of the chief accounts, upon which wit it ſelf is delightful, is, in very many caſes, the unexpectedneſs of the things that pleaſe us; that unexpectedneſs being the higheſt degree of novelty, which, as I freſhly noted, does exceedingly gratify moſt men's minds. We need not in this caſe, as in moſt others, make an uneaſy preparation to entertain our inſtructors; for our inſtructions are ſuddenly, and, as it were out of an ambuſcade, ſhot into our mind from things, whence we never expected them, ſo that we receive the advantage of learning good leſſons, without the trouble of going to ſchool for them, which to many appears the greateſt trouble, that is to be undergone, for the acquiſt of knowledge. But though theſe irradiations of light be oftentimes ſudden, as that which we receive from flaſhes of lightning, yet it is not always upon the ſingle account of this ſuddenneſs, that the inſtructions, preſented us by occaſional meditations, have an unexpectedneſs; for oftentimes, the ſubject, that is conſidered, appears not to be any thing at all of kin to the notion it ſuggeſts. And there are many of theſe reflections, whoſe titles, though they name the occaſion of them, do ſo little aſſiſt, even an ingenious reader, to gueſs what they contain, that if you tell him what is treated of, he will ſcarce imagine, how ſuch thoughts can be made to have a relation to ſuch remote ſubjects; and the informations we receive from many creatures, and occurrences, are oftentimes extremely diſtant from what, one would conjecture to be the moſt obvious, and natural thoughts thoſe themes are fitted to preſent us; though, when the circumſtances are thoroughly examined, and conſidered, the informations appear proper enough. Thus, when a navigator ſuddenly ſpies an unknown veſſel afar off, before he has hailed her, he can ſcarcely, if at all, conclude what he ſhall learn by her; and he may from a ſhip, that he finds perhaps upon ſome remoter coaſt of *Africa*, or the *Indies*, meet with informations concerning his own country, and affairs. And thus ſometimes a little flower may point us to the ſun, and by caſting our eyes down to our feet, we may in the water ſee thoſe ſtars, that ſhine in the firmament, or higheſt viſible heaven.

CHAP. II.

AND laſtly, the pleaſantneſs of theſe meditations to him, that hath attained ſkill in making them, will, if he be not much mortified, be much increaſed by their being proofs, as well as effects, of ſkill. To be able to take up inſtructions in books, that are repleniſhed with them, and where they are purpoſely and diſtinctly exhibited in the form of inſtructions, requires rather that a man be docile than ingenious: but to be able to collect moral and ſpiritual documents out of a book of hieroglyphicks, or from a landſkip or a map, is more than every attentive conſiderer can do, and is that, which argues ſomething of dexterouſneſs and ſagacity, that is not very ordinary. And ſo, from ethical or theological compoſures, to take out leſſons, that may improve the mind, is a thing much inferiour to the being able to do the like out of the book of nature, where moſt matters, that are not phyſical, if they ſeem not to be purpoſely veiled, are at leaſt but darkly hinted. And methinks there is ſuch a difference betwixt him, that but takes up inſtructions in books of morality and devotion, and him that by occaſional reflections derives them from the book of nature, and the accidents he chances to take notice of, as there is betwixt an ant, that contributes nothing either to the production or improvement of the corn ſhe lays up and feeds on, but only carries away that, which ſhe finds ready formed into its little granary or repoſitory; and the induſtrious bee, who, without ſtealing from flowers any thing that can prejudice them, does not only gather, but improve and transform her food, and live on that, which otherwiſe would be uſeleſs; and beſides, not only has the pleaſure to gather its food from flowers, and from variety of them, but lives upon honey, an aliment, that is as ſweet and delicious as nutritive. It was doubtleſs a very great pleaſure to *Æſop*, that by his ingenious fictions he could, in a manner, lend reaſon and ſpeech to lions, foxes, crows, and other animals, to whom nature had denied both; and I know not why it ſhould be leſs delightful, by occaſional reflections, to turn not only birds and beaſts, but all kinds of creatures in the world, as well mute and inanimate, as irrational, not only into teachers of ethicks, but oftentimes into doctors of divinity, and by compelling ſenſeleſs creatures to reveal truths to us, that they were never acquainted with themſelves, perform really ſomething like that, which was but pretended by the ancient augurs and other diviners the heathen world admired; who took upon them, by the caſual flights of birds, and the inſpection of the intrails of beaſts, to learn the will

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of heaven. It is a piece of ſkill, for which mathematicians have been deſervedly admired, and which is little leſs pleaſing to thoſe that have it, than wonderful to thoſe that have it not, that as if artiſts were able to preſcribe to the ſun and moon, and the reſt of the luminous globes of heaven, both their pace and their ſtages, they can make that inexhauſted fountain of light, at ſo immenſe a diſtance, by the ſhadow of a little gnomon, fitly placed, give us an exact account of all the journeys he performs in the zodiack: but perhaps, it is neither a leſs noble nor a leſs delightful piece of ſkill, to be able, by an innocent kind of necromancy, to conſult the dead, and conjure up worm-eaten carcaſes out of their moſſy graves, without fearing to hear from them ſuch diſmal diſcourſes, as *Saul* had from dead *Samuel*, and to make, not the ſtars only, but all the creatures of nature, and the various occurrences that can fall under our notice, conſpire to inrich us with inſtructions they never meant us; ſince the motion of the celeſtial lights are known, certain, and invariable; but theſe particulars are neither to be defined by number, nor limited by rules. Not to ſay, that this ſecret does as much excel that other, which recommends aſtronomy, as wiſdom does ſcience, and is as much the more uſeful of the two, as to know how to paſs away our time is more profitable, than to know how our time paſſes away.

But there is a fourth particular, which, though ſomewhat leſs directly than the three I have already diſcourſed of, may be reduced to the pleaſantneſs of occaſional meditations; and it is, that whereas our innate ſelf-love is wont to make any thing, that minds us of our faults, exceedingly uneaſy and unwelcome; in the diſcoveries, that, by this way of thinking, are made us of what is amiſs, the uneaſineſs is very much allayed, and the pill very well gilt. For there are two main things, that conduce to the ſweetning of reproofs, and to keep men from being offended at them; the one is, when they come from a perſon, whom we love, and whom we believe to love us, and to have no other deſign in diſpleaſing us than that of ſerving us: and the other is, that the diſcovery, that is made us of our faults, be ſweetned by acknowledgments of our having qualities of a commendable nature, whence wiſe reprovers uſually mingle, and, as it were, brew their reprehenſions with praiſes. Now, both theſe pleaſing vehicles, if I may ſo call them, and correctives of reproofs, concur in thoſe we meet with in making occaſional reflections. For, in theſe caſes, being our own inſtructors, and our own conſciences being the makers of the application, we cannot ſuſpect the reprehenſions to come from perſons, that either miſtake us, or are partial againſt us; and that truth, which a man's conſcience applies to him, being found out by the ſagacity of his own underſtanding, extracting from objects that, which every conſiderer would not have picked out thence; it may very often happen, that the ſame reflection will diſcover to a man his excellencies, as well as make him take notice of his faults: and that which makes him condemn the diſorders of his affections, may argue, and thereby commend, the goodneſs of his parts.

CHAP. III.

I Know, it may be objected againſt the pleaſantneſs of the mental exerciſe I have been ſpeaking of, that to make occaſional meditations is a work too difficult to be delightful.

In anſwer to this, I might repreſent, that there are employments, wherein their being attended with ſomewhat of difficulty, is ſo far from deterring us, that it recommends them: as we ſee, that in hunting and hawking, the toil, that muſt be undergone, is ſo much an indearment of the recreation, of which it makes a great part, that when it happens, that we do not meet with difficulties enough, we create new ones; as when huntſmen give the hare law, (as they ſpeak) for fear of killing her, before they have almoſt killed their horſes, and perhaps themſelves, in following her. Yet I ſhall rather chuſe to make a more direct anſwer, by obſerving, that the difficulties imagined in the practice I am treating of ſeem to ariſe, not ſo much from the nature of the thing it ſelf, as from ſome prejudices and miſapprehenſions, that are entertained about it, eſpecially the following two.

The firſt is a needleſs ſcruple, which makes ſome fancy themſelves obliged to confine their thoughts to the ſubject, that ſet them on work. And this dwelling long upon one theme is to many men a thing uneaſy and tedious enough. But for my part, I ſee no neceſſity of ſuch a ſtrictneſs; and I have often obſerved the thoughts ſucceſsfully to follow objects of a quite differing nature from thoſe that were firſt ſtarted, from which perhaps, though more obſtinately purſued, very little inſtruction or advantage would have been obtained. And it not unfrequeutly happens, that men trouble themſelves in vain to make any profitable uſe of the conſiderations of thoſe firſt objects, where the thoughts being licenſed to expatiate themſelves, they do often at length pitch upon ſomewhat or other that is inſtructive, and at which, perhaps, they aimed at the very firſt, though they attained it by degrees, and purſued it by winding and untraced ways. As when we let a grey-hound looſe in a warren, we confine him not to the firſt rabbit he makes after, ſince we ſee it frequently happens, that one ſets him a running, and another proves his quarry. Nor do I conceive ſuch a practice diſagreeable to the nature of occaſional meditations, nor to be excluded by their name; for that appellation may well enough be applied to thoſe emergent thoughts, which fortuitous occaſions did awaken or ſuggeſt to us; nor is it neceſſary, that our thoughts be always calculated for the ſubject that excited them, provided we thence took occaſion to think; ſo that in ſome caſes, the occaſion is not ſo much the theme of the meditation, as the riſe. For my part, I am ſo little ſcrupulous in this matter, that I would not confine occaſional meditations to divinity it ſelf, though that be a very comprehenſive ſubject; but am ready

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to allow men's thoughts to expatiate much farther, and to make of the objects they contemplate not only a theological and a moral, but alſo a political, and œconomical, or even a phyſical uſe. And I doubt, whether the groundleſs imagination, that occaſional reflections ought to be confined to matters of devotion, or, at furtheſt, of morality, have not much helped to keep our Meleteticks ſo little cultivated, as hitherto they have been. And indeed there is ſo perfect an harmony, and ſo near a kindred, betwixt truths, that, in many caſes, the one does either find out, or fairly hint or elſe illuſtrate or confirm, the other. And it is no wonder, that divers of them ſhould belong to the ſame object, and be deduced from it. And if men were ſollicitous to apply the things they take notice of in occaſional objects, to the diſcovery or illuſtration of œconomical, political, or phyſical matters, it would probably bring ſuch kind of thoughts more into requeſt with ſeveral ſorts of men, and poſſibly conduce to the improvement of thoſe parts of knowledge themſelves.

CHAP. IV.

THE other thing I propoſed to mention, as that, which diſcourages many from the addicting themſelves to make occaſional meditations, is a fancy, that to practiſe this kind of thinking, one is obliged to the trouble of writing down every occaſional reflection, that employs his thoughts; and they conclude it far eaſier to forbear making any, than to write down all. But to do this, were to undertake a taſk no leſs unneceſſary than tedious. Thoſe meditations indeed, that have ſome excellency in them, that fits them to inſtruct others, ſhould for that purpoſe be kept from periſhing; and thoſe that were not conceived without ſome extraordinary affection in a man's ſelf, ſhould be carefully purſued, as bellows to blow or rekindle devotion, by reminding us of the devout thoughts the like objects had excited in us. But for the reſt of our occaſional reflections, though they fill our heads, they need not employ our hands, as having performed all the ſervice, that need be expected from them, within the mind already.

NOR would I have any man be diſcouraged from this way of thinking, that cannot expreſs ſo much wit or eloquence in occaſional meditations, as perhaps he may aſpire to. For, beſides that much ſubtilty of wit is not to be expected, or at leaſt exacted, in this kind of compoſures, where we commonly make uſe of things rather out of haſte than choice, as frequently being but the firſt thoughts we meet with, not the beſt we have; beſides this, I ſay, that which ought moſt to endear this ſort of reflections to a Chriſtian, is rather that they cheriſh piety, than that they expreſs wit, and help to make the man good, whether or no they make his ſtyle be thought ſo. It were injurious to nature to fancy, that the fig-tree derives no benefit from the rain and ſun, becauſe they do not make it, like other trees, flouriſh with bloſſoms, more gaudy than neceſſary; though without previous buds it brings forth welcome fruits. Not to add, that the difficulty of framing occaſional meditations need not be eſtimated by that, which we find when we firſt addict ourſelves to the making of them; for practice will by degrees ſo much leſſen that difficulty, that after a while we ſhall find, that occaſional thoughts will need but ſmall invitation to frequent thoſe minds, where they meet with a kind entertainment. And though men ſhould be reduced to purchaſe this habitude at the rate of a little difficulty, I doubt not but they will find the benefit of it, when gotten, richly to recompenſe the trouble of acquiring it. Nor will the practice, that muſt contribute to the attainment of a reaſonable degree of ſkill in making them, be half ſo troubleſome when thoſe exerciſes but make up the habitude, as they will prove facile and delightful when they flow from it.

SECT. III.

CHAP. I.

THE third grand advantage, that may be derived from the cuſtom of making occaſional meditations, is, that it conduces to the exerciſe and improvement of divers of the faculties of the mind. And this it may do upon ſeveral accounts.

1. FOR, in the firſt place, it accuſtoms a man to an attentive obſervation of the objects, wherewith he is converſant. Whereas there is ſcarce any thing, that may not prove the ſubject of an occaſional meditation; ſo the natural propenſity we have to manage well the themes we undertake to handle, unperceivably ingages us to pry into the ſeveral attributes and relations of the things we conſider, to obtain the greater plenty of particulars, for the making up of the more full and compleat parallel betwixt the things, whoſe reſemblances we would ſet forth. By which means a man often comes to diſcover a multitude of particulars, even in obvious things, which, without ſuch an ingagement to attention, he would never have minded, and which common beholders take no notice of. And though it may ſeem, that the habit, produced by the practice of occaſional meditating, ſhould accuſtom a man to heed only ſuch objects, as are like to ſuggeſt to him devout thoughts; yet, not to mention now, that I ſhall advertiſe you anon, that there is no neceſſity of confining occaſional meditations to matters devout or theological, I ſhall only repreſent, that, ſince we know not, before we have conſidered the particular objects that occur to us, which of them will, and which of them will not, afford us the ſubject of an occaſional reflection, the mind will, after a while, be ingaged to a general and habitual attention, relating to the objects, that preſent themſelves to it. Beſides that though we ſhould at firſt apply our heedfulneſs to circumſtances of only ſome few ſorts of objects; yet the habit being once acquired, would eaſily reach to others than thoſe that firſt occaſioned it: as men, that by learning to ſing anthems are come to have critical ears, will be able to judge, much better than they could before, of the reſemblances and differences of tones

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tones in other ſongs, and will take notice of divers particularities in voices, which would not be heeded by an unpractiſed ear. And as we have made it appear, that the way of thinking, we would recommend, does very much diſpoſe men to an attentive frame of mind; ſo, that ſuch a frame or diſpoſition is a great advantage in the whole courſe of a man's life, will not appear improbable to him, who duly conſiders, that ſince attention, like a magnifying glaſs, ſhews us, even in common objects, divers particularities, undiſcerned by thoſe who want that advantage, it muſt needs make the things, he is converſant with, afford the conſiderer much more of inſtruction than they obtrude upon the ordinary regardleſs beholder; and, conſequently, this exerciſe of the mind muſt prove a compendious way to experience, and make it attainable without grey-hairs: for that, we know, conſiſts not in the multitude of years, but of obſervations, from numbers and variety of which it reſults. Nor is there any reaſon, why prudence ſhould be peculiarly aſcribed to the aged, except a ſuppoſition, that ſuch perſons, by having lived long in the world, have had the opportunity of many and various occurrences to ripen their judgment: ſo that if one man can by his attention make, as well he may in a ſmall compaſs of time, as great a number of obſervations as leſs heedful perſons are wont to do in a longer, I ſee not, why ſuch a man's experience may not be equal to his that has lived longer; for it matters not much, whether a man make a competent number of obſervations, in much time or in little, provided he have made them well.

CHAP. II.

THE practice I would recommend, accuſtoms a man to make reflections upon the things he takes notice of, and ſo, by exerciſing, improves his reaſoning faculty. For, as moſt men have much more ſtrength and agility in the right hand than in the left; and, generally ſpeaking, thoſe limbs of the body that are moſt exerciſed, are ſtronger than the reſt of the ſame kind; ſo the faculties of the mind are improved by exerciſe, and thoſe, that we frequently employ, grow thereby the more vigorous and nimble. And, for my part, I have been often inclined to think, that the chief advantage, that the reaſoning faculty derives from the inſtitution received in logic-ſchools, comes not ſo much from the precepts themſelves, which are pretended to make up an art of reaſoning, as from the frequent exerciſes, that, by occaſion of ſuch precepts, the ſtudents are put upon. And, perhaps, if men were obliged to read the controverſies of ſubtile wits, and to engage in frequent diſputations, both premeditated and extemporary, it would add little leſs of readineſs and acuteneſs to their wits, though they diſputed of other matters than ſuch as properly belong to logic, and were not before imbued with the precepts of that art: as we ſee, that the uſe of ſinging with thoſe, that can ſing well, does much improve one's voice, both as to ſtrength and clearneſs, whatever the tunes or ſongs be, that are ſung, and how little ſoever thoſe, with whom one ſings, make it their buſineſs to teach him the art of muſic.

BUT this is only conjecture; and whether it be true or no, yet this I am confident is ſo, that the bringing of a man to be a thinking and a reflecting perſon is to procure him ſo great an advantage, as though it were the only one may juſtly endear to him the cuſtom of making occaſional meditations; and he, that could bring this practice into the requeſt it deſerves, would do a greater piece of ſervice, not only to the particular perſons he perſuades, but to mankind in general, than the greater part of good men themſelves ſeem to be aware of. For though God having been pleaſed to make reaſon the chief part of our nature, among the various objects, that daily occur to us, it can ſcarce be, but that ſome or other will in a manner obtrude ſome notions even upon the unattentive; yet certainly, all that has been found worthy of mankind in mathematics, philoſophy, and other kinds of learning, has been attained by thinking men, or by a frequent and regular practice of employing the thoughts. And leſt it ſhould be objected, that theſe various and elaborate effects of aſſiduous meditation, were the productions only of philoſophers, or other men of ſpeculative heads; let us but conſider, that though gallants and courtiers do ſeldom love to tire themſelves with thinking, and are as ſeldom fond of writing books, not to add, fit to write them; and though love be not the fruitfulleſt, that may be pitched on, yet that paſſion, and ſome particulars relating to it, frequently buſying their thoughts, and being ſeveral ways conſidered by them, has been diſplayed and contrived even by ſuch writers, as I have been juſt now mentioning, into thoſe numerous plays, that daily employ the ſtage, and thoſe voluminous romances, that are too often the only books, which make up the libraries of gallants, and fill the cloſets of ladies. He that moſt truly called himſelf the *Truth*, tells us, that the devil is not only a *lyar*, but the *father of lyes*, that is, the great patron and promoter of falſhood, and, as ſuch, he ſtudiouſly oppoſes all uſeful truths; not only thoſe, for which we muſt be beholden to revelation, but thoſe alſo, which may be attained by ratiocination, and the well-regulated exerciſe of our natural faculties; and he were much leſs an adverſary and an old ſerpent than he is, if his enmity to God and man did not juſtly make him think, that ſcarce any thing is more his intereſt than ſollicitouſly to divert men from thinking, and diſcourage them in it, there being few things, whereby he could more effectually oppoſe at once both the glory of God, and the good of men. And ſure, if ſo ſubtile an adverſary did not think it very much his intereſt to be ſollicitous about this matter, it could not be, that men ſhould chuſe for a privilege, the laying aſide that faculty of meditating, which is indeed ſo much their privilege, that, if experience did not convince the contrary, I could never ſuſpect that the non-employing of their thoughts could be their choice rather than their puniſhment; and that

John viii. 44.

rational

rational creatures, eſpecially profeſſing Chriſtianity, ſhould either keep idle, or confine to employments worſe than idleneſs, ſo noble and improveable a faculty, that enables an ingenious man to pry into the inmoſt receſſes of myſterious nature, and diſcover there ſo much of the wiſdom, power, and goodneſs of the Author, as are moſt fit to give the diſcoverer a high and devout veneration for thoſe excellencies. A faculty, whereby an inquiſitive ſoul may expatiate itſelf through the whole immenſity of the univerſe, and be her own teacher in a thouſand caſes, where the book is no leſs delightful than the leſſons are inſtructive: A faculty (to conclude) by whoſe help the reſtleſs mind having dived to the lowermoſt parts of the earth, can thence in a trice take ſuch a flight, that having traverſed all the corporeal heavens, and ſcorned to ſuffer herſelf to be confined within the very limits of the world, ſhe roves about in the ultra-mundane ſpaces, and conſiders how far they reach.

CHAP. III.

III. BESIDES the two already mentioned advantages, which the intellectual part of the mind may derive from the practice of occaſional reflections, I ſhould not ſcruple to add a third, if there were not too juſt cauſe of apprehending, that my writings may diſcredit any thing, that comes propoſed of that nature by no better a pen, and that the manner of what I am about to deliver may diſparage the matter. But ſince, from the experience even of purblind and dim-ſighted perſons, good perſpectives may be, not improperly, nor unſucceſsfully, recommended, though their native and peculiar debility of ſight keep them from being able to ſee as clear and as far through ſuch glaſſes as other men can do, if themſelves can, by the uſe of them, do far more than they could without them; I will adventure to ſpeak of an improvement I cannot boaſt of, left by ſuppreſſing the mention of an advantage, becauſe I cannot make it, I ſhould ſeem either vain, or envious, as well as dull. I ſhall then take notice, that the Meleteticks we are conſidering, may, where it finds a capable and diſpoſed ſubject, much improve that nimble and acceptable faculty of the mind, whereby ſome men have a readineſs and ſubtilty in conceiving things, and a quickneſs and neatneſs in expreſſing them; all which the cuſtom of ſpeaking comprehends under the name of wit; which pleaſing, and (if well managed) uſeful quality, the exerciſe I am diſcourſing of may three or four ſeveral ways promote.

FOR (firſt) the accuſtoming one's ſelf to make extemporal reflections, and that upon all kind of occaſions, does by degrees bring the mind to a readineſs of conception, which keeps a man from being eaſily ſurprized by the ſubject he has occaſion to conſider, and enables him oftentimes to ſurprize his hearers; and that ſuch a kind of ſurprize is one of the moſt endearing circumſtances of the productions of wit, he muſt not have much conſidered the nature of them, that ignores.

NEXT, the ſame exerciſe inures a man to draw his conceptions from the very nature of the thing he ſpeaks of; which, among thoſe that can judge of wit, is held a far greater ſign of it, than the ſaying things more ſpecious and elaborate, that appear to be antienter than the occaſion; as is uſual in epigrams, and other ſolemn premeditated pieces of wit, where oftentimes the thoughts were not made for the themes, but before them: whereas the ſuddenneſs of a good occaſional reflection, and its congruity to that which gave it riſe, perſuades the hearers, that the ſpeaker's wit is of its own growth, and is rather ſuggeſted by the occaſion, than barely applied to it.

A THIRD way, whereby our Meleteticks may conduce to wit, is, by bringing thoſe, that uſe to write their thoughts, to what may be called a certain *ſuppleneſs of ſtyle*: for when a man treats of familiar, or of ſolemn ſubjects, he is ſo much aſſiſted by the received phraſes and manners of ſpeaking, that are wont to be imployed about them, that being ſeldom at a loſs for convenient expreſſions, his wit is ſeldom diſtreſſed how to furniſh him with words fit for his turn. But the ſubjects, that invite occaſional reflections, are ſo various and uncommon, and oftentimes ſo odd, that, to accommodate one's diſcourſe to them, the vulgar and received forms of ſpeech will afford him but little aſſiſtance; and to come off any thing well, he muſt exerciſe his invention, and put it upon coining various and new expreſſions, to ſuit that variety of unfamiliar ſubjects, and of occaſions, that the objects of his meditation will engage him to write of. And by this difficult exerciſe of his inventive faculty, he may by degrees ſo improve it, and, after a while, attain to ſo pliant a ſtyle, that ſcarce any thought will puzzle him to fit words to it, and he will be able to cut out expreſſions, and make them ſit cloſe to ſuch ſubjects, as a perſon unaccuſtomed to ſuch kind of compoſures would find it very difficult to write of, with any thing of propriety.

CHAP. IV.

IT remains, that I mention one way more, and that a conſiderable one, whereby the practice of occaſional reflections may contribute to the improvement of wit; and that is, by ſupplying men with ſtore and variety of good compariſons.

HOW great, and how acceptable, a part of wit that is, which has the advantage to be expreſſed by apt ſimilitudes, every man's own experience, if he pleaſe to conſult it, may, in ſome meaſure, inform him. And certainly, there is no one part of wit, that is ſo generally applicable to all kind of perſons; for good compariſons ſerve equally to illuſtrate, and to perſuade; the greateſt wits diſdain them not, and even ordinary wits are capable to underſtand them, and to be affected by them: and if a ſermon, or a long diſcourſe, be enriched with one apt compariſon, what part ſoever elſe be forgotten, that will be ſure to be remembred. And a but plauſible argument, dreſſed up in fine ſimilitudes, ſhall be more prevalent

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among the generality of men, than a demonſtration propoſed in a naked ſyllogiſm; and therefore, the ancient ſages did ſo much chuſe to imploy a figurative way of delivering their thoughts, that when they could not furniſh themſelves with reſemblances fit for their turns, they would deviſe parables, and apologues, to recommend what they ſaid to the attention and memory of thoſe they would work upon. And thoſe famous orators, who, though they lived in commonwealths, did, by their eloquence, exerciſe a more than monarchical government there, and who, by their inchanting tongues, ruled thoſe warlike people, whoſe ſwords had made them maſters of the world; thoſe imperial wits, I ſay, whoſe oratory performed ſuch wonders, performed them chiefly by the help of their happy compariſons, which alone contributed more to their ſucceſs, than almoſt all the other perſuaſive figures of their triumphant rhetorick: lucky compariſons being indeed thoſe parts of wit, that as well make the ſtrongeſt impreſſions upon the mind, as they leave the deepeſt on the memory. Now, as the being furniſhed with apt compariſons does ſo very much conduce to the making a man's diſcourſes and writings appear witty, ſo there is ſcarce any thing more fit and likely to ſupply a man with ſtore and variety of compariſons, than the cuſtom of making occaſional meditations; for he, that uſes himſelf to take notice of the properties and circumſtances of moſt things that occur to him, and to reflect on many of them, and thereby obſerves the relations of things to one another, and conſequently diſcerns, how the properties or circumſtances of one may be accommodated, by way of reſemblance or diſſimilitude, to ſomewhat that relates to the other, will often find, beſides thoſe things which afford him his occaſional reflection, divers others, which, though leſs fit for the meditation, that invited his taking notice of them, may be very fitly applicable to other ſubjects and purpoſes, and will eaſily furniſh him with reſemblances, wherewith he may, if he pleaſes, much increaſe the books of ſimilitudes, already extant. And the compariſons, that may be this way lighted on, may ſometimes prove ſtrange, and unobvious enough, to be ſurpriſing even to himſelf, as well as to his auditors, or his readers.

CHAP. V.

BUT, beſides thoſe ſimilitudes we may be furniſhed with by the things we obſerve, without turning them into occaſional meditations, we may find in thoſe very ſubjects, whereon we do make reflections, circumſtances, that, though improper, or at leaſt unneceſſary, to be taken into the occaſional meditation, may be very fitly accommodated to other things, and plentifully contribute to the ſtore and variety of compariſons we lately mentioned. This muſt appear ſo much a truth, to any that is exerciſed in making occaſional reflections, that I ſhould perhaps forbear to illuſtrate it, by any particular example, but that this part of my diſcourſe recalls into my mind ſome thoughts, that were ſuggeſted to me by one of the laſt occaſions I had, to make reflections of this nature. I ſhall add then, that being all alone, and diverted a pretty while by a ſudden ſtorm of thunder, lightning, wind, and rain, from the imployments I had deſigned my ſelf to, I had the unwelcome leiſure to make ſome reflections upon the rude objects, that obtruded themſelves upon my obſervation.

AND the chief thing, that preſented itſelf to my thoughts, was a reſemblance betwixt prophane or atheiſtical wits, and the black clouds that then over-caſt the ſky: for, as thoſe clouds are raiſed to an elevated ſtation, and do afford flaſhes of light; ſo theſe irreligious wits are oftentimes conſpicuous enough, and may bring forth notions, that are ſurpriſing, and inſtructive. But as the ſame clouds, whilſt they give us but heir own momentany light, obſcure (by darkning the ſky) and hinder us, as much as they can, from receiving that of the ſun, which reaches further, and is many other ways preferable to vaniſhing coruſcations; ſo theſe wits, whilſt they ſeem to enlighten thoſe they dazzle, with their own new opinions, do really deprive them of the true heavenly light, that would elſe ſhine forth to them in the revealed word of God. And as the light, that we do receive from the clouds, may dazzle and aſtoniſh us, but is not ſufficient for us to travel by; ſo the admired reaſonings of theſe ſophiſters may ſurprize and amaze us, but will never prove ſufficient to be, like the ſcripture, a conſtant *lamp unto our feet, and a light unto our paths.* And as the light afforded by ſuch clouds is not only wont to be attended with affrighting thunder, and hurtful ſtorms, but burns, and deſtroys, or at leaſt ſcorches, and blacks, where it paſſes, and oftentimes falls upon churches, hoſpitals, colleges, and brings ſuch frights and ruins whereſoever it comes, that it were a great deal better men wanted the light of ſuch flaſhes, than that they ſhould be expoſed to ſuch inconveniencies by them; ſo the inſolent and irregular wits, I am ſpeaking of, do not only make an unwelcome noiſe in the world, but do oftentimes ſo denigrate the reputation of them that oppoſe them, and bear ſo little reſpect even to things ſacred, or uſeful to mankind, without ſparing the church or ſeminaries of learning, if either come in their way, that they do far more miſchiefs by their errors, or their practices, than the little inſtruction they give us is able to make amends for. Pſal. cxix. 105.

THIS, if I forget not, was the ſubſtance of the occaſional meditation ſuggeſted to me by the ſtorm; but, beſides that, there are in this ſome particulars, which are not neceſſary to the meditation it ſelf, and may be fitly enough accommodated, by way of compariſons, to other occaſions. I remember, the ſame ſubject (the ſtorm) had other circumſtances in it, fit to afford ſimilitudes applicable to other ſubjects, and ſome of them unobvious enough. For inſtance, it is not eaſy to find ſo illuſtrious a compariſon, to ſet forth, how the moſt contrary qualities may proceed from the ſame ſubjects,

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ſubjects, as that which we may be ſupplied with, by conſidering, that from the ſame clouds we derive both light and darkneſs; and a noble compariſon of contraries, conjoined in one ſubject, may be borrowed from the ſame clouds, which afford us lightning, and rain, ſhew that they contain in them two of the eminenteſt and ſeldomeſt conſiſtent contraries of nature, fire and water. And another compariſon may be derived from the differing productions of theſe clouds, to illuſtrate thoſe things, which do at once both much good and much miſchief, or ſometimes the one, and ſometimes the other: for the ſame clouds both produce the thunder, and the lightning, and thereby blaſt trees, kill men and beaſts, fire houſes, and ruin the nobleſt buildings, without ſparing churches themſelves; and, on the other ſide, plentifully afford us thoſe refreſhing and fertilizing ſhowers, that correct the heat of the ſultry air, and cure the barrenneſs of the parched earth. And one that is ſkilled in framing compariſons out of diſſimilitudes, and exerciſed in the other ways of turning and winding of ſimile's, may eaſily enough find, in the ſubject we have been conſidering, circumſtances capable of being conveniently enough accommodated to more ſubjects and purpoſes, than I have leiſure now to take notice of. And ſince, as the being able to find the latent reſemblances betwixt things ſeemingly unlike, makes up a great part of what we are wont to call wit; ſo the being able to diſcern the unobvious diſparities of things manifeſtly reſembling is one of the chief things, that diſplays the faculty men call judgment. And ſince both theſe are very much aſſiſted by the cuſtom of making reflections, wherein we muſt take notice of the ſeveral properties, wherein things either are alike, or diſagree; methinks it ſhould not a little manifeſt the uſefulneſs of our Meleteticks towards the improvement of men's parts, that they not only inſtruct the more ſerious faculty of the ſoul, but ſharpen the more ſubtile.

CHAP. VI.

IV. BUT the practice I have all this while been recommending, does not only diſpoſe us to attention, in obſerving the things that occur to us, and accuſtom us to reflect on them ſeriouſly, and expreſs them fitly; but does alſo, though inſenſibly, ſuggeſt to us ways and methods, whereby to make the objects we conſider informative to us.

FOR by example, analogy, or ſome of thoſe other ways, which we may be invited, on another occaſion, to inſiſt on, we are, as it were, led by the hand to the diſcovery of divers uſeful notions, eſpecially practical, which elſe we ſhould not take any notice of. And indeed the world is the great book, not ſo much of nature, as of the God of nature, which we ſhould find even crouded with inſtructive leſſons, if we had but the ſkill, and would take the pains, to extract and pick them out. The creatures are the true Ægyptian hieroglyphicks, that under the rude forms of birds, and beaſts, *&c.* conceal the myſterious ſecrets of knowledge, and of piety. And as chemiſts boaſt of their elixir, that it will turn the ignobleſt metals into gold; ſo wiſdom makes all objects, on which it operates, inrich the poſſeſſor with uſeful and precious thoughts. And ſince even the illiterate huſbandman can, with the moſt abject dung it ſelf, give a flouriſhing growth to the moſt uſeful grains, to medicinable herbs, and even to fragrant flowers; why may not a wiſe man, by the meaneſt creatures, and ſlightedeſt object, give a conſiderable improvement to the nobleſt faculties of the ſoul, and the moſt lovely qualities of the mind?

BUT the particular method of deriving inſtruction from the ſubjects we conſider will be more fit to be particularly inſiſted on, when we ſhall have more time, or ſome other opportunity, to treat of the manner of making occaſional meditations; and ſhew, how they may be fetched from example, analogy, diſſimilitude, ratiocination, and other topicks, which we muſt not now take any further notice of.

SECT. IV.

CHAP. I.

HITHERTO we have conſidered the benefits, that may be afforded by the practice of occaſional meditations to the *intellectual faculties*. We will now proceed to the advantages, that may accure from the ſame practice to the *will and affections*; theſe advantages being not only the moſt valuable in themſelves, but thoſe, upon whoſe account I have been engaged in the preſent undertaking.

V. THE laſt therefore and greateſt benefit I ſhall take notice of, in the practice I would invite you to, is, that it awakens good thoughts, and excites good motions in the will and affections. For ſince we have already manifeſted, that it is wont to ſuggeſt variety of notions to the meditator, and ſuch as are uſually accompained with delight; this friendly property to devotion, which I now aſcribe to our Meleteticks, is a very eaſy and genuine off-ſpring of the marriage of the two others: the beams of knowledge, acquired by ſuch reflections, having in them, like thoſe of the ſun, not only light, but heat. And indeed it were ſomewhat ſtrange, as well as ſad, if a perſon diſpoſed and accuſtomed to obſerve and conſider, converſing with ſuch inſtructive books as thoſe of God's creatures and his providence, with an intention to take out practical leſſons, ſhould not find them. For amidſt that rich variety of objects, that in differing manners proffer themſelves to his conſideration, and ſuggeſt to him a great diverſity of reflections, it cannot reaſonably be imagined, that he ſhould not find ſubjects or circumſtances, that are proper, either to afford him examples to imitate, or ſhew him the danger, or unhandſomneſs, or inconvenience of ſomething that he ſhould avoid, or raiſe his thoughts and affections heaven-wards, or furniſh him with ſome new practical conſideration, or ſhew him ſome known truth in a varied and his

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delightful dreſs, or (at leaſt) recall ſome notions his frailty makes him need to be put in mind of, or, in a word, either refreſh his memory, or otherwiſe cheriſh his devotion. Let us ſuppoſe a perſon, who being qualified and accuſtomed to reflect upon various objects that occur to him, mainly deſigns, in the exerciſe of that faculty, the warming of his affections, and the improvement of his piety; and we ſhall ſcarce doubt, but when he looks about him in the world, he will find it, what one of the fathers loftily ſtyled it, παιδευτηρίον τῆς θεογνωσίας καὶ ψυχῶν λογικῶν διδασκαλίον, (a ſchool for rational ſouls to learn the knowledge of God.) There is ſcarce any thing, that nature has made, or that men do or ſuffer, though the theme ſeem never ſo low and ſlight, whence the devout reflector cannot take an occaſion of an aſpiring meditation: as in a hopeful morning the humble lark can, from the loweſt furrow in the field, take a ſoaring flight towards heaven, and aſcend thitherward with a melody, that delights both herſelf and her hearers. If ſuch a perſon conſiders, how amongſt ſuch an admirable variety, and ſuch odd antipathies of the numberleſs creatures that compoſe the univerſe, the conſtant obſervation of the laws of their nature makes them univerſally, and, as it were, unanimouſly, to conſpire to make the author of it appear wonderful in it; he cannot but be willingly poſſeſſed with ſuch an awful admiration of the matchleſs wiſdom of their great diſpoſer, as made the Pſalmiſt cry out, upon a ſomewhat like occaſion, * *How manifold are thy works, O Lord, how wiſely haſt thou made them all?* If he have occaſion to conſider the merciful diſpenſations of divine providence to the godly, or to take notice of the ſevere inflictions of divine juſtice on the wicked, he will find himſelf powerfully engaged to rely on the one, and to apprehend provoking the other. If he take notice, that the world is but our ſtorehouſe, and that multitudes of admirable creatures ſeem to have had a being given them, principally for the uſe of undeſerving man; inſomuch that many of the beaſts, and birds, and fiſhes, are but our caters for one another; he will burſt out into mental, if not vocal, expreſſions of thankfulneſs and humiliation to the father of mercies, for ſo unmerited and ill returned a bounty, and will be apt to ſay with *David, What is man, that thou takeſt knowledge of him; or the ſon of man, that thou makeſt account of him?* And if he compare this munificence of God, in daily giving ſo many creatures, that never violate the laws of their nature, nor endeavour to diſappoint him of his ends in creating them, for the neceſſities, nay, for the pleaſures, of rebellious and unthankful man; he will reſent an ingenuous ſhame, and a noble diſdain, that that creature ſhould be of all the leaſt grateful, that has received the moſt benefits, and that he ſhould of all others prove the moſt unruly, who alone has been endowed with reaſon to rule himſelf withal. If in a ſtarry night he looks upon the firmament, and conſiders how many fixed ſtars there are, and how many thouſand times more there might be without wanting room, the leaſt of which aſtronomers teach us to be far bigger than the whole earth, which yet, by the probableſt computation, contains above ten thouſand millions of cubick German leagues, (and conſequently above threeſcore times as many *Engliſh* miles of ſolid meaſure) he will find abundant cauſe to exclaim with *David*, *When I conſider thy heavens, the work of thy hands, the moon and ſtars which thou haſt ordained, what is man, that thou ſhouldſt be mindful of him, or the ſon of man, that thou viſiteſt him?*

Pſal. civ. 24.

Pſal. cxliv. 3.

Pſal. viii. 3, 4.

CHAP. II.

AND ſince our diſcourſe has led us to the mention of a text, where the truly inſpired poet (who, by his omitting to ſpeak of the ſun, ſeems to have compoſed this pſalm in the night) makes the moon the chief ſubject of his meditation; it will not perhaps be amiſs, if, on this occaſion, we add a few ſhort reflections on the ſame theme, and thereby confirm what we lately noted about the differing reflections and ſimilitudes, which may be afforded by the ſame ſubject, as its ſeveral attributes may be differingly conſidered.

IF then, in the firſt place, when our contemplator takes notice of the greateſt brightneſs of the moon, he remembers too, that it is when ſhe is at the full, that ſhe is ſubject to be eclipſed; it would put him in mind of the mutability of human things, and that oftentimes proſperity proves never the more ſecure for appearing the more full and reſplendent.

NEXT, our reflector may find in the moon a lively emblem of a true miniſter of the goſpel. For, as the moon communicates to the earth the light, and that only, which ſhe receives from the ſun; ſo the Apoſtles, and firſt preachers of Chriſtianity, and (in their meaſure) their true ſucceſſors, communicate to mankind the light, which themſelves have received from the bright ſun of righteouſneſs. And the ſimilitude may be advanced, by adding, that as the moon ſhines not on the earth, with any other beams than thoſe ſhe derives from that fountain of light, the ſun; ſo the true preachers of the heavenly doctrine mingle not their own inventions, or human traditions, with that pure and ſincere light of revelation they are employed to diſpenſe: it being ſafeſt, and moſt deſirable, for the church, that Chriſtians ſhould receive the bread of life, as the Jews are recorded to have received the material bread, in a paſſage of St. *Matthew*'s goſpel, where it is ſaid, that Chriſt firſt brake, and gave to the diſciples, the bread, which they afterwards, from him, diſtributed to the people; ſo that they might each of them, in a literal ſenſe, imploy that expreſſion of St. *Paul*, *I have received of the Lord, that which I delivered unto you.*

Mat. xv. 36.

1 Cor. xi. 3.

AND

* So *Junius* and *Tremellius* tranſlate the place, *Quàm ample ſunt opera tua, O Jehova, quàm ea omnia ſapienter feciſti?* and ſo the original will bear, if the Hebrew *Ma* be made applicable as well to the latter, as to the former part of the words.

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AND as though the moon be deſtitute of native light, yet by virtue of that borrowed one, which ſhe plentifully receives from the ſun, ſhe affords more to men than any of the ſtars, which, upon the ſcore of their vaſt diſtance from the ſun, are, by modern Naturaliſts, ſuppoſed to ſhine by their own light; ſo thoſe illiterate fiſhermen, whom the ſon of righteouſneſs called, and made the light of the world, did, by virtue of the copious irradiations he vouchſafed them, diffuſe far more light to mankind, than the greateſt philoſophers, that, being unaſſiſted by divine revelation, had only their own native beams to ſhine with.

AND as oftentimes the ſame ſubject, but as variouſly conſidered, may afford both ſomewhat fit to be ſhunned, and ſomewhat fit to be imitated; ſo, in that, which we ſuppoſe our reflector now conſidering, he may eaſily diſcern the emblem of an ungrateful perſon. For as the moon, though ſhe receive all the light that ennobles her from the ſun, does yet, when ſhe is admitted to the neareſt conjunction with him, eclipſe that bright planet, to which ſhe owes all her ſplendor; ſo unthankful men abuſe thoſe very favours, that ſhould endear to them their benefactors, to the prejudice of thoſe that oblige them.

AND 'tis like, that our reflector may, by the way, take notice, that as what paſſes betwixt the moon and the ſun, does thus afford him a ſimile, whereby to ſet forth ingratitude; ſo what paſſes betwixt the moon and the ſea may ſupply him with an example of the contrary quality, and put him in mind, that a thankful man will be true and obſequious to his benefactor, though the perſon that obliged him have loſt that proſperity, that before made him conſpicuous, and attracted vulgar eyes; as the ſea follows the courſe of the moon, not only when ſhe ſhines upon it with her full light, but when at the change ſhe can communicate little or no light to it.

TO the two above-mentioned attributes, upon whoſe account the moon afforded a compariſon for human proſperity, and another for preachers of the Goſpel, we will now add, that ſhe may afford us a ſimilitude to ſet forth a liberal perſon by; for as the moon freely communicates to the earth the light ſhe receives from the ſun, ſo the bountiful perſon imparts to indigent men the largeſſes he receives from the exuberant goodneſs of God. And as to intellectual communications, the parallel will hold further, ſince as the moon enjoys not the leſs light, for her imparting ſo much to the earth; ſo in mental communications liberality does not impoveriſh, and thoſe excellent gifts ceaſe not to be poſſeſſed by being imparted. And it is very poſſible, (to add that upon the bye) that after the light of the moon has (according to what I lately noted) repreſented to our contemplator the qualifications of a preacher, it may alſo put him in mind of the duty of a hearer. For, as it were very fooliſh in us, and unthankful towards the father of lights, not to make uſe of the great light we receive from the ſun by the moon, or not to acknowledge the moon to be a very uſeful creature, upon the ſcore of that light, wherewith ſhe ſhines upon the earth, though, in her, that light be deſtitute of heat; ſo it were unwiſe and ungrateful for hearers to refuſe to acknowledge, or to be guided by, the conſpicuous endowments of learning and eloquence, that God vouchſafes to great ſcholars, though they themſelves were but illuſtrated, not warmed by the beams they reflect. But therefore, as oyſters, and other ſhell-fiſh, are obſerved to thrive at the increaſe of the moon, though her light be unattended with heat, and though even when ſhe is at full, ſhe wants not her ſpots; ſo devout hearers will be careful to proſper proportionably to the inſtructions they receive even from thoſe preachers, whoſe illuminations are unaccompanied with zeal and charity, and who, when they ſhine with the greateſt luſtre, are not free from their darkneſſes, as to ſome points, or from notorious blemiſhes.

AND as the moon may thus furniſh our contemplator with ſimilitudes, to ſet forth both a virtue and a vice of the mind, ſo may it ſupply him with an emblem of its condition: for as the light of the moon is ſometimes increaſing, and ſometimes in the wane, and not only is ſometimes totally eclipſed, but even when ſhe is at the full, is never free from dark ſpots; ſo the mind of man, nay, even of a Chriſtian, is but partly enlightened, and partly in the dark, and is ſometimes more, and ſometimes leſs, illuſtrated by the beams of heavenly light, and joy; and not alone now and then quite eclipſed by diſconſolate deſertions, but even when it receives the moſt light, and ſhines the brighteſt, knows but in part, and is in part blemiſhed by its native darkneſſes, and imperfections. And theſe reſemblances are not ſo appropriated to the mind of man, but that they might eaſily be ſhewn to be applicable to his condition, in point of outward proſperity, and adverſity. And to theſe reſemblances other reflections on the ſeveral adjuncts of the moon might be alſo added, together with ſeveral examples of this nature on other ſubjects, were it not, that I think my ſelf to have ſpent time enough already upon a theme, that fell but incidentally under my conſideration; and were it not alſo, that the reflections, which might here be annexed upon the attributes of other objects, may be more properly ſubjoined to what may be on another occaſion preſented to you, by way of illuſtration of ſome particulars, that belong to the fourth part of the precedent ſection, in which my haſte, and ſome other reaſons, made me content my ſelf, to give ſome few general hints about ſuch reflections, and an intimation of the topicks, whence I am wont to fetch them.

CHAP. III.

AND having given you this advertiſement, *en paſſant*, we may now proceed a little further, and add, that if we ſuppoſe our contemplator's thoughts to deſcend from heaven to earth, the far greater multitude and variety of objects, they will meet with here below,

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will ſuggeſt to them much more numerous reflections. But becauſe ſo ſpacious a field for meditation as the whole earth would afford to us too vaſt a theme to be attempted on this occaſion, we will confine our contemplator to his garden, or rather to any one of the trees of it, and take notice, not of all the meditations he might fetch thence, but only of four or five of the conſiderableſt of thoſe, that the viewing it may, as he walks by at ſeveral times, ſupply him with.

If then, in the ſpring of the year, our reflector ſees the gardener pruning a fruit-tree, we may ſuppoſe him invited by that object, to reaſon thus within himſelf: Though one, that were a ſtranger to the art of gardening, would think, that that man is an enemy to this tree, and goes about to deſtroy it, ſince he falls upon and wounds it, with a ſharp iron, and ſtrikes off ſeveral of its youthful parts, as if he meant to cut it in pieces; yet he that knows, that the gardener's arm is not ſet on work by anger, but by ſkill, will not conclude, that he hates the tree he thus wounds, but that he has a mind to have it fruitful, and judges theſe harſh means the fitteſt to produce that deſirable effect. And thus, whatever a man, unacquainted with the ways and deſigns of providence may ſurmiſe, when he ſees the church not only expoſed to the common afflictions of human ſocieties, (for that is but like our tree's being expoſed to be weather-beaten by winds, and rain) but diſtreſſed by ſuch perſecutions, as ſeem to be divine inflictions, that invite men to ſay of the body, what the prophet foretold ſhould be ſaid of the head, *We eſteemed him ſtricken, ſmitten of God, and afflicted:* whatever, I ſay, a carnal, or a moral, man would be apt to imagine, upon ſight of the churches diſtreſſes, the knowing Chriſtian will not from thence infer, that God hates her, or that he has abandoned her; ſince it is he, that loved his church ſo well, as to give himſelf for it, who declares, that as many as he loves, he rebukes and chaſtens. And this is ſo fitly applicable alſo to particular believers, that the divine ſon of the great * γεωργὸς does not only give us cauſe to think, that afflictions do not ſuppoſe God's hate, but to hope that they may not always ſuppoſe man's guilt, but ſometimes rather aim at his improvement; ſince they are the memorable words of our Saviour, ſpeaking of his father, *Every branch in me, that beareth not fruit, he taketh away, and every branch that beareth fruit, he purgeth it, that it may bring forth more fruit.* And it may ſomewhat illuſtrate the ſimilitude to add, that the huſbandman uſes only to prune the trees of his garden, not thoſe that grow wild in his woods; but though he oftner wound theſe, yet he wounds the other more fatally, imploying but the pruning-hook to pare off the ſuperfluous twigs, or, at moſt, branches, of the one, whilſt he lays the ax to the root of the other, to fell the tree it ſelf.

Isaiah liii. 4.

John xv. 2.

* *That is, Cultivator of the ground.*

John xv. 2.

But theſe are not the only thoughts, which the pruning of a fruit-tree may ſuggeſt to our reflector: for if he conſiders, that by cutting off ſeveral of the parts of the tree, and by nailing many of the reſt to the wall, the gardener does not only ſecure the tree from being blown down, or torn, by the rudeneſs of boiſterous winds, but makes it look well ſhaped; ſo the divine huſbandman, (as we have lately ſeen God ſtyled in the ſcripture) by the wiſe, and ſeaſonable, though ſeemingly rigorous, and uſually unwelcome, culture, he imploys upon thoſe children of his, whom he afflicts, does not only protect them from ſeveral dangers, whereto, without thoſe harſh reſtraints, they would be expoſed; but as he makes them amends in point of ſafety for what he denies them in point of liberty, ſo he adorns them by wounding them; his kind and ſkilful ſtrokes adding as much to the beauty of a Chriſtian's mind, as they cut away from the ſuperfluities of his fortune; for the preſſures of affliction do give ſuch ſmoothneſs and gloſs to the ſoul, that bears them patiently and reſignedly, that the heathen moraliſt ventured to ſay, that if there were any ſpectacle here below noble enough, and worthy to entertain the eyes of God, it was that of a good man, generouſly contending with ill fortune. And the hyperbole (though after this manner ſomewhat loftily expreſſed) will appear the leſs ſtrange to him, that conſiders, that *Job* had not only his patience, when it had been tried to the uttermoſt, crowned with a fortune double to that, which had been the faireſt in the Eaſt; but before his conſtancy was tried near ſo far, received that much higher recompence of an honour never vouchſafed to mortals until then, when God himſelf did not only approve, but (if I may ſo ſpeak with reverence) make his boaſt of, a man: *Haſt thou conſidered* (ſays he to man's great enemy) *my ſervant* Job, *that there is none like him in the earth, a perfect, and an upright man, one that feareth God, and eſcheweth evil? and ſtill he holdeth faſt his integrity, although thou movedſt me againſt him to deſtroy him without a cauſe.* Sure one may call him more than happy *Job*, ſince, if, as *David* tells us, the *man is happy, whoſe ſins God is pleaſed to cover*; what may that man be accounted, whoſe graces he vouchſafes to proclaim?

Job ii. 3.

Pſ. xxxii. 1.

CHAP. IV.

And as the conſideration of the pruning of trees, under the notion of *that which wounds them*, may afford our contemplator the reflections already pointed at; ſo the conſidering of the ſame action, under another notion, may lead him to reflections of another nature: for if he obſerves, that, in certain caſes, gardeners oftentimes do not only prune away all the ſuckers, and many of the luxuriant ſprigs, but cut off ſome of the branches themſelves, provided they ſpare the maſter-boughs; and yet theſe amputations, tho' they take much from the tree, are deſign'd to add to the fruit, as accordingly they are wont to do: if, I ſay, our reflector takes notice of this, it may eaſily ſupply him with an illuſtration of what he may have obſerved among ſome men, who, by afflictions

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flictions, even in point of fortune, are brought to be far more charitable, than they would have been, if their peace and plenty had continued unimpaired. As, beſides that St. *Paul*, ſpeaking of the *Macedonian* churches, gives them this character, *That in a great trial of affliction, the abundance of their joy, and their deep poverty, abounded unto the riches of their liberality*; we have in *Zaccheus* a memorable inſtance to our preſent purpoſe, ſince, after his repentance had, by his own conſent, cut off from his eſtate more than all that ſlander, oppreſſion, and other unjuſt ways of getting, (which uſed to bring in but too great a part of a publican's) had added to it; he gave away more, out of the remainder of his eſtate, than every liberal man would have done out of the whole. His wealth, like a ſkilfully pruned tree, bore the more fruit to piety; for having had ſome parts of it cut away, he grew rich (in good works) by being deſpoiled, and his charity increaſed as much as his fortune was leſſened.

2 Cor. viii. 2.

Luke xix.

If, towards the end of the ſpring, our reflector ſee the ground under his tree ſtrowed with the bloſſoms, that time and winds may have caſt down thence, it is like it would furniſh him with this conſideration; That, as though the bloſſoms are in themſelves great ornaments to a tree, and oftentimes both uſeful and pleaſant things, yet to be ſeaſonably deprived of them, is not a miſchief to the tree that loſes them; ſince, till the bloſſoms are gone, the fruit, which is a better and more laſting thing, and more principally intended by nature, cannot be had: ſo it will not always follow, that becauſe certain things are in their kind deſirable, and therefore may be reckoned among goods, the loſs or depravation of them muſt neceſſarily be an evil. And ſo, though a fair and healthy body may be look'd upon as a bleſſing, yet it will not follow, that a *death* (as the Scripture ſpeaks) either *in* or *for the Lord*, becauſe it throws this flouriſhing body to the ground, and makes it rot there, muſt needs be a deplorable evil: ſince, as the bloſſoms falling off, is, according to the courſe of nature, neceſſarily previous to the formation, or, at leaſt, the perfection, of the fruit; ſo the being deprived of this life is, according to God's ordination, a neceſſary antecedent to our being enriched with thoſe more ſolid and durable bleſſings of perfect virtue and happineſs.

Οἱ ἐν Κυρίῳ ἀποθνήσκοντες. Rev. xiv. 13.

And if, whilſt our contemplator's tree is adorn'd with leaves, as well as bloſſoms, (as we often ſee ſeveral of the former come before all the latter are gone) he chance to take notice, how buſy the bees are in ſucking theſe, whilſt they leave the others untouch'd, he may peradventure make this, or ſome ſuch other reflection on it; That, though the leaves be not only ornaments of a tree, but productions, often uſeful to ſhade and ſhelter the fruit, and are of a more ſolid texture, and a more durable nature than the bloſſoms, which ſeem to be of a ſlighter make, and rather gawdy and delightful than laſting; yet it is not about the leaves, but the bloſſoms, that the induſtrious bee aſſiduouſly imploys her time, as ſucking from thoſe gaudy productions of the tree ſtore of that honey, which the leaves would not afford her.

Thus, though the books written about dogmatical and controverſial points in divinity, may be in their kind valuable, and uſeful productions of ſkill in theology, and may ſeem more ſtrong and ſubſtantial compoſures, and likely to retain their reputations longer, than books of devotion; yet it is of theſe, rather than thoſe, that the devout Chriſtian will be a ſolicitous peruſer; ſince it is not from barren, though ſolid aſſertions or diſputes, but from florid and pathetical books of devotion, which firſt allure the reader, and then affect him, that the devout ſoul extracts her honey, I mean, thoſe celeſtial pleaſures, that reſult from, as well as maintain, a free communion with God, which does at once both exerciſe her devotion, and recompenſe it, and afford her, as flowers do the bee, an aliment equally nutritive and delicious.

And he may ſomewhat illuſtrate, as well as continue, the alluſion further, by conſidering, that ſilk-worms, that live upon leaves, and bees, that feed on flowers and bloſſoms, do indeed both of them thrive upon their reſpective aliments, and are thereby enabled to preſent men with uſeful productions, but with this difference; that the ſubtile threads of ſilkworms ſerve principally to cloath others, whereas the honey, that is elaborated by the bee, does not only ſupply others with a healing and cleanſing medicine in ſome diſtempers, but affords a great deal of pleaſure to the bee herſelf: for thus, though as well the diligent ſtudiers of ſpeculative and polemical divinity, as the careful peruſers of books of devotion, may be advantaged by what they ſtudy; yet this difference may be obſerved betwixt them, that the former may, by the diſcourſes they read, be aſſiſted to write others of the like nature, whereby their readers may be enabled to talk with more acuteneſs, and applauſe; but the latter may not only be aſſiſted by making ſuch compoſures, as they aſſiduouſly converſe with, to contribute to the cleanſing of men's conſciences from dead works, and as well pacify the troubles of their minds, as heal the wounds, which ſchiſm or ſcandal may have given to the church; but do often, in the firſt place, feel themſelves all the joys, and advantages, they would procure to others, and they happily find pious reflections, devout ſoliloquies, ardent ejaculations, and other mental entertainments of a religious ſoul, to be of a nature not only ſo ſweet, but ſo improving, and ſo advantageous, that whilſt many other laudable imployments recommend us to the ſtudents of theology, theſe more eſpecially recommend us to the Author of it, and indear us to God himſelf.

If, when our fruit-tree has changed its white livery for a green, our conſiderer chance to take notice, how thick it is ſet with leaves, of which it had not one ſome months before, it may poſſibly put him in mind of the inſtability of their condition, that are undeſervedly envied for a numerous train of ſuch ſeeming friends, and gaudy attendants, as are ſo to the fortune, rather than the perſon: for, as in the ſun-ſhiny

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months of ſummer, when the fair weather would keep the tree warm enough, without the help of leaves, it is wont to be cover'd with thoſe verdant ornaments; but loſes them all in winter, when it needs their ſhelter from the rigors of that cold ſeaſon: ſo thoſe, that during the ſun-ſhine of proſperity, are beſet with ſeeming friends, of which they had no need, find themſelves left naked, and forſaken of them all, when adverſity would make their company of ſome advantage. If our contemplator chance to obſerve, how his tree flouriſhes with verdant leaves, and gaudy bloſſoms, at that ſeaſon of the year, when it is providing to bring forth fruit, it may put him in mind of the pleaſedneſs and alacrity, with which a charitable perſon ſhould ſet himſelf to the doing of good; and mind him, that as the God of nature loves a chearful giver, ſo the temper of a liberal perſon is pointed out by nature her ſelf in a tree, which ſeems to triumph in all the ornaments it can put on, when it is about to exhauſt the greateſt part of its own ſtock of ſap, to produce fruits, which only others are to eat.

If he take notice of the order, wherein it is uſual for the leaves and bloſſoms to precede the fruit, it may poſſibly invite him to look with a more favourable eye upon the green and immature eſſays of early writers, if they diſcover, that the author aims at good things, though he does not yet perform great ones: for, however theſe youthful productions of the pen are commonly rather pleaſing and florid, than otherwiſe conſiderable; yet if they be good for their ſeaſon, and in their kind, though that kind itſelf be not of the uſefulleſt, they may deſerve pardon, and perhaps encouragement; ſince, though they be not yet ſolid, they may promiſe ſomething that will be ſo; and even the beſt trees preſent us their bloſſoms, before they give us their fruit.

If the ſame contemplator happens to ſee young people firſt ſhake the tree in vain, and then climb it to gather unripe fruit, it may afford him a repreſentation of men's over-eager and untimely perſuits of ſeveral deſirable things, and eſpecially of honour: for, as green fruit, though of a good kind, will not eaſily be ſhaken down by them, that would gather it, but reduces them either to climb the tree, or forcibly ſtrike it off, which commonly bruiſes, and disfigures what it procures; and as the fruit, when thus obtain'd, is but ſour, and unwholſome, being neither ſweetened, nor concocted by maturity; ſo that it uſually both ſets the teeth on edge, and breeds ſickneſs in the body; whereas, if the ſame fruit were let alone till it were fully ripe, and in ſeaſon, it would both readily drop into the eater's mouth, and prove delicious, and more wholſome food; ſo, when we greedily purſue after honour, and pleaſure, of which this life is not the proper ſeaſon, we not only meet with difficulties in acquiring them, but find not, in poſſeſſing them, either that ſatisfaction, or that advantage, that the eagerneſs of our unruly appetites promiſes us; whereas, if we would ſtay contentedly till God's time be come (which is always the beſt, and fitteſt) we ſhould not ſteal, or force, but receive unfading honours, and uncloying delights, by being preſented with *incorruptible crowns of glory*, by him, *with whom there is fulneſs of joy, and at whoſe right hand* (the ſtation deſigned for thoſe, that overcome the world's allurements, and their own impatience) *there are pleaſures for evermore*; that is, eternal ones. 1 Pet. v. 4. Pſal. xvi. 11.

Lastly, if towards the end of ſummer, or of autumn, our reflector, coming to viſit his inſtructive tree, find it preſent him ſtore of fruit, and perhaps obſerves it to be grown taller ſince the laſt winter, each bough will afford him a lively emblem of a true believer. For, as the loaded branch makes uſe of the moiſture it attracts from the dirty ground, to recede as much as it can from the earth, and ſpends its ſap in ſhooting up towards heaven, and bearing fruit for men; ſo the devout Chriſtian improves the bleſſings he receives of this inferior world, to elevate his mind above it; and the uſe, that he makes of earthly goods, and advantages, is to raiſe his grateful ſoul nearer to God, and diſpenſe them by works of charity to men.

CHAP. V.

THESE, *Sophronia*, are ſome, and but ſome, of the thoughts, which the occaſional conſideration of a fruit-tree might ſuggeſt to a conſidering perſon. And if we ſhould lead our reflector from the garden to the woods, or to the river-ſide, or into the fields, or to the ſtreet, or to a library, or to the exchange; or, in a word, to I know not how many other places I could name, I have ſome reaſon to think, that each of them would ſupply him with variety of occaſional meditations. Wherefore, ſince the want of themes will not, it is fit that ſomewhat elſe ſhould, place bounds to this diſcourſe. And ſince by finding, that I myſelf begin to be weary of writing, I have too much cauſe to fear, that you are quite tired with reading, I think it high time to haſten to a concluſion: only, before I make one, I muſt do our Meleteticks the right to advertiſe you, that you would do them wrong, if you ſhould imagine, that in the paſſed diſcourſe I have either carefully enumerated, or fully diſplay'd, the advantages, which a devout and ingenious contemplator may derive from the exerciſe of the ways of thinking I have been treating of. For, though I have in the paſt diſcourſe, eſpecially thoſe parts of it, that are contained in the third precedent, and in this preſent fourth ſection, ſaid enough to recommend the ſubject to any that is not much indiſpoſed to be prevailed with; yet I will not deny, but that, even in thoſe two ſections, I have left much unſaid.

For, beſides the ſeveral advantages and ways of making occaſional meditations already pointed at, there are other accounts, upon which the practice I would perſuade may both benefit a pious ſoul, and be made uſe of by an ingenious one. For the reſpects one thing may have to another are ſo numberleſs, and the mind of a rational man, verſed in meditations,

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may compound and disjoin notions ſo many ways, and may make ſuch inferences from them, and ſuch applications of them, that it frequently happens, that beſides the reflection, ſuggeſted by that which gave the firſt riſe to his meditations, he lights upon conceits differing enough from them, and perhaps better than they: as when hounds, hunting a hare, meet in their way with a ſtag. For, though philoſophers ſeem to have juſtly enough rejected the opinion, attributed to *Plato*, *that all knowledge is but reminiſcence*; yet certainly the mind of a man, well furniſhed with variety of notions, is, by the analogy or contrariety of things and notions, in reference to each other, ſo eaſily and readily excited to lay them together, and diſcourſe upon them, that he is oftentimes by any ſlight occaſion helped to light (and that with a ſtrange and ſurprizing facility) upon things, that he would elſe have ſcarce taken the leaſt notice of. When the mind is once ſet on work, though the occaſion adminiſtered the firſt thoughts, yet thoſe thoughts themſelves may, as well as the object that excited them, become the themes of further meditation: and the connection of thoughts within the mind may be, and frequently is, ſo latent, and ſo ſtrange, that the meditator will oftentimes admire to ſee, how far the notions he is at length led to, are removed from thoſe, which the firſt riſe of his meditation ſuggeſted. And by theſe incidental excurſions he may ſometimes be as much delighted and ſurpriſed, as *Sampſon* was, when going aſide to look upon the carcaſe of a lion, he met with a ſtock of honey.

Judges xiv. 8.

BUT I can add one thing towards the inducing you to exerciſe your ſelf in the way of thinking we have all this while been ſpeaking of; which though I had almoſt forgot to take notice of, it will, I doubt not, ſeem important to *Sophronia*, to whom it need not be a diſcouragement from aiming at one of the nobleſt uſes of occaſional reflections, that it ſuppoſes not a bare acquaintance with them, but ſprings from an entire, and (if I may ſo ſpeak) intimate familiarity with our Meleteticks. For this uſe of occaſional meditations, though it do but gradually differ from ſome of thoſe, that have been already mentioned, will perhaps by the devout (and conſequently by *Sophronia*) be eſteemed the higheſt advantage, that this way of thinking can confer; and it is, that the cuſtom of making occaſional reflections may inſenſibly, and by unperceived degrees, work the ſoul to a certain frame, or temper, which may not improperly be called heavenly-mindedneſs, whereby ſhe acquires an aptitude and diſpoſition to make pious reflections upon almoſt every occurrence, and oftentimes without particularly deſigning it. But as this privilege will, as I was intimating, ſcarce fall to the ſhare of any but thoſe, that, by long or frequent exerciſe, have ſo accuſtomed their minds to reflect upon what they ſee, that they continue that practice, as it were, of their own accord; ſo when once, by ſuch a conſtant kindneſs and hoſpitableneſs to ſuch thoughts, that they will, as it were, come to the mind without calling, and make themſelves its gueſts, without particular invitations, the ſoul has attained that deſirable frame we lately called heavenly-mindedneſs, which is a diſpoſition and a readineſs to make ſpiritual uſes of earthly things, both the advantage and the delight of that frame of heart cannot but be extraordinary. It muſt ſurely afford a great deal of ſatisfaction to an ingenious and devout perſon, to be able to make the world both his library and his oratory; and which way ſoever he turns his eyes (not only upon unobvious things, but even upon the moſt familiar ones) to behold ſomething that inſtructs, or that delights him; and to find, that almoſt every object, that preſents it ſelf to his notice, preſents alſo good thoughts to his mind, to be gathered with as much innocency and pleaſure, and with as little prejudice to the things, that afford them, as honey is gathered by the induſtrious bee from the differing flowers ſhe meets with in her way. Certainly, if we would carefully lay hold on, and duly manage, this help, it would prove a powerful remedy to prevent or cure much of that dullneſs and drouſineſs, that do ſo frequently ſmother or blemiſh our devotion. There would ſcarce any thing paſs us, out of which we would not ſtrike ſome ſpark or other of that heavenly fire, or that would not contribute ſomething, either to kindle it, or to feed it, or to revive it. If but half the precious time we impertinently trifle, or ſquander away, upon employments, that will be ſure to coſt us either tears or bluſhes, were careſully laid out in the cultivating of this kind of thoughts, it might often ſave our miniſters the labour of inſiſting ſo long upon the uſes of their doctrines, when the whole world would be a pulpit, every creature turn a preacher, and almoſt every accident ſuggeſt an uſe of inſtruction, reproof, or exhortation. No burial but would toll a paſſing-bell, to put us in mind of our mortality: no feaſt but would make us aſpire to the marriage-feaſt of the lamb: no croſs but would add to our deſires to be diſſolv'd, and to be with Chriſt: no mercy but would be a freſh engagement unto obedience to ſo good a maſter, as the author of it: no happineſs of others, but would prove an encouragement to ſerve him, that can give that, and much greater: no miſery of others, but would awake and heighten our gratitude, that we are privileged from it: no ſin in our neighbours, that would not diſſuade us from what we ſee looked ſo unhandſomely in others: nor any virtue of theirs, but would excite our emulation, and ſpur us on to imitate or ſurpaſs it. In a word, when the devout ſoul is come to make that true uſe of the creatures, as to look upon them as men do upon water, that the ſun gilds with his beams, that is, not ſo much for it ſelf as for the reflective virtue it has to repreſent a more glorious object; and when ſhe has, by long practice, accuſtomed her ſelf to ſpiritualize all the objects and accidents that occur to her, I ſee not why that practice may not be one of

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the moſt effectual means for making good that magnificent aſſertion of the Apoſtle, That *all things work together for good to them that love God:* a devout occaſional meditation, from how low a theme ſoever it takes its riſe, being like *Jacob*'s ladder, whereof though *the foot leaned on the earth, the top reached up to heaven.*

Rom. viii. 28.

Gen. xxviii. 12

OCCASIONAL REFLECTIONS.

SECT. I.

REFLECTION I.

Upon his manner of giving meat to his dog.

IGNORANTLY thankful creature, thou beggeſt in ſuch a way, that by what would appear an antedated gratitude, if it were not a deſignleſs action, the manner of thy petitioning before-hand rewards the grant of thy requeſt; thy addreſſes and recompence being ſo made and ordered, that the meat I caſt thee may very well feed religion in me. For, but obſerve this dog, I hold him out meat, and my inviting voice loudly encourages and invites him to take it: it is held indeed higher than he can leap; and yet, if he leap not at it, I do not give it him; but if he do, I let it fall half way into his mouth. Not unreſemblingly deals God with us; he ſhews and holds forth to us (the ſoul's true aliment) eternal glory, and his moſt gracious word ſummons and animates us to attempt it. Alas! it is far above the reach of our endeavours, and our deſerts; and yet if we aſpire not to it, and ſtrive not for it, in vain do we expect it; but if we faithfully do what in us lies, and our endeavours ſtrain themſelves to their utmoſt, God mercifully allows the will for the effect, meaſures our performances by what they aim'd at, and favourably accepting what we can do, for what we ſhould do, he ſupplies the imperfections of our faint, but yet aſpiring attempts, by ſtooping condeſcenſions; and what our endeavours want of reaching up to, his grace and acceptation brings down. Piety is the condition, though not the price, of heaven; and (like the wedding garment in the parable) though it give us not a right to the beatifick feaſt, is, yet that, without which none ſhall be admitted as a duly qualified gueſt: for though we cannot reach heaven by our good works, we ſhall not obtain it without them.

REFLECTION II.

Upon his diſtilling ſpirit of roſes in a limbick.

ONE, that knew how well I love the ſcent of roſes, and were ignorant of the uſes of this way of diſtillation, would, queſtionleſs, think me very ill adviſed, thus haſtily to deprive my ſelf of the flowers I moſt love, and employ art to make them wither ſooner than nature would condemn them to do: but thoſe that know, both the fading condition of flowers, (which, unimprov'd by art, delight but whilſt they are, what they cannot long be, freſh) and the exalting efficacy of this kind of diſtillation, will think this artificial way, that chymiſts take, of ſpoiling them, is an effect as well of their providence as their ſkill: for that pleaſing and ſprightly ſcent, that makes the roſe ſo welcome to us, is as ſhort-lived and periſhing, as the flower, that harbours it, is fading; and though my limbick ſhould not, yet a few days inevitably would, make all theſe roſes wither. But by this way of ordering my roſes, though I cannot preſerve them, I can preſerve that ſpirituous and æthereal part of them, for whoſe ſake it is, that I ſo much prize and cheriſh this ſort of flowers; which, by this means, I preſerve, not indeed in the fading body, but in the nobler and abſtracted quinteſſence; which purer and laſtinger portion of them will be more highly fragrant than ordinary roſes are wont to be, even whilſt they are freſh, in that ſeaſon, when thoſe flowers, that have not been thus early and purpoſely deſtroyed, will, according to the courſe of nature, whereto they are left, wither and putrify.

THUS he that ſees a charitable perſon liberally part with that money, which others are ſo fond of, if he be a ſtranger to the operations of faith, and the promiſes of the goſpel, he will be apt to miſtake the Chriſtian's liberality for folly, or profuſion, and to think that he is fallen out with his money: but he that remembers, how clear a proſpect, and how abſolute a diſpoſal of the future, the Scripture of truth (to uſe an angel's expreſſion) aſcribes to him, that bid his diſciples *make themſelves friends with the uncertain (or unfaithful) mammon*, (for ſo the uſe I ſometimes meet with of the Greek word, together with the context, invites me to render it) *that when he fail, they may receive us into everlaſting habitations*; and he that ſhall likewiſe conſider, not only the tranſitory nature of worldly poſſeſſions, (from which their periſhing, or ours, will be ſure ere long to divorce us) but the ineſtimable advantage, with which we ſhall receive in heaven whatever we employ in pious uſes

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uſes here on earth, will conclude this way of parting with our wealth the ſureſt and gainfulleſt way of preſerving it; ſince the Chriſtian, by parting but with what (however) he could not long keep, ſhall, through God's munificent goodneſs, obtain a much more valuable treaſure, that he ſhall never loſe: ſo that thus to ſacrifice wealth to charity is not an early loſs of it, but the right way of ſecuring it; for by this gainful way, when we ſhall, in another world, be paſt the poſſibility of poſſeſſing our riches in kind, ſuch an employment of them may help us to enjoy them, though not in the capacity of riches, yet in that noble capacity of goods, under which notion alone they are deſirable; and thus laid up they may there procure us, what they could never here afford us, happineſs.

REFLECTION III.

Upon his being in great danger wandring, on Mendip *hills, among covered lead mines, that he knew not of.*

HOW have I travelled all this while upon the brink of the grave! I thought only to be out of my way, but little dreamed to be ſo near the end of all my journeys, in that of my life by traverſing to and fro amongſt thoſe deep and covered pits, upon any one of which if my horſe had but chanced to ſtumble, (and the very mine-men I at length met with, think it a kind of miracle he did not) I had been killed and buried at once, and my fate had been for ever as much concealed from my friends as my body: and all this eſcape a work ſo totally of God's goodneſs, that I did not ſo much as know my danger till I was paſt it; ſo that it ſeemed ſent, but to give me occaſion of rejoicing in my deliverance. How vaſt a debt of gratitude then do I owe to God? and how extremely do I fall ſhort of acquitting my ſelf of it? ſince, beſides that I make him but very unſuitable returns for the bleſſings I know I have received, I receive from him ſignal bleſſings, that I do not ſo much as know of, and which conſequently I am very unlike particularly to acknowledge. But this gracious reſcue, from ſo great and unexpected a hazard, ſhall, I hope, teach me henceforth to beware, both of ſecurity, ſince I often fall into dangers that I know not, and of diſtruſts of God's providence, ſince I have found it ſo watchful to deliver me from thoſe that I feared not.

REFLECTION IV.

His horſe ſtumbling in a very fair way.

HERE is a patch of way, to which any leſs ſmooth than a bowling-green were rugged, and in which it ſeems not only ſo unlikely, but ſo difficult, for a horſe to trip, that nothing could have made me believe a horſe could have ſtumbled here, but that mine has dangerouſlydone ſo. This jade has this very evening carried me ſafely through ways, where ſtumbles were ſo much to be expected, that they were to have been forgiven; and now in a place ſo ſmooth, that ſure he could not faulter in it, only out of curioſity and trial, he falls under me ſo lubberly, that I as much admired my eſcape as danger. But it is too uſual with us, unfaulteringly to traverſe adverſity's rough ways, and ſtumble in proſperity's ſmootheſt paths. The obſervation is almoſt as old as proſperity, that fortune ruins more perſons whilſt ſhe embraces them, than whilſt ſhe would cruſh them: but though the obſervation be very common, it is not more ſo, than it is to ſee even thoſe, that make it, add to the inſtances that juſtify it. I have ſeldom yet been ſo fortunate, as to be obnoxious to that leſs frequently pitied than diſarming danger: Fortune has ſeldom yet vouchſafed to turn Syren to pervert me; and ſhe has hitherto given me much more exerciſe for my conſtancy than for my moderation. I think too, that without ſlandering my ſelf, I may confeſs, that I have ſometimes wiſhed my ſelf in the liſts with that bewitching enemy, proſperity; and increaſed the number of thoſe many, who never think ſo fair an adverſary formidable, till they find themſelves vanquiſhed by her: but upon ſecond thoughts, I judge it better, to leave the choice of my antagoniſt to him, who not only beſt knows my ſtrength, but gives it me; eſpecially, when I conſider, that as we are all of us naturally ſuch ſtumblers, that (as *Solomon* ſpeaks in ſomewhat another ſenſe,) *even the juſt man falls ſeven times a day*, ſo it is obſerved in ſtumblers, that they are moſt ſo in fair way; into which if providence lead my ſteps, I ſhall think it ſeaſonable to pray, *and lead us not into temptation*; and ſhall not think it unſeaſonable to remember, that ice is at once the ſmootheſt and the ſlippereſt of ways, and that (the jadiſhneſs of our natures well conſidered) there is no way, wherein we ought to travel with more heed, than that, whoſe treacherous evenneſs would divert us from taking heed to our way.

Prov. xxiv. 16.

REFLECTION V.

Upon two very miſerable beggars, begging together by the high-way.

BEHOLD this fore-moſt wretch, whoſe ſtrange deformity and ghaſtly ſores equally exact our pity and our horror; he ſeems ſo fit an object for compaſſion, that not to exerciſe it towards him can ſcarce proceed from any other cauſe than the not having any at all: the ſadneſs of his condition is augmented by his want of eyes to ſee it; and his miſery is ſuch, that it calls for an increaſe of pity, by his being ſo diſtracted, as to deſire a longer life, or rather longer death: he ſues more movingly to the eye than to the ear; and does petition much leſs by what he ſays, than what he is: each ſeveral member of his tortured body is a new motive to compaſſion, and every part of it ſo loudly pleads for pity, that (as of ſcolds) it may (in another ſenſe) be ſaid of him, that he is all tongue. But yet this other beggar thinks not his condition the leſs deplorable for his companion's being the

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the more ſo: he finds in the diſeaſes of his fellow as little conſolation as cure; nor does he at all think himſelf ſupplied with a deficient hand, becauſe the other wants one. And therefore he is as importunate for relief, as if all miſeries were not only heaped on him, but confined to him: his fellow's burthen lightens not his load; and if fortune never had perſecuted any other, he could not more deplore nor reſent her perſecutions. So that, if we ſhould judge of their miſeries rather by the ear than by the eye, this latter's ſadder complaints would move us to decree him the advantage in point of wretchedneſs.

TRANSLATE now, my ſoul, all this unto ſpirituals; and as we meaſure the ſtraightneſs of lines, not by a ram's horn, but a ruler; ſo be not thou ſo raſh, as to infer thy health from others more forlorn and deſperate diſeaſes. Let not the greater difficulty of another's cure leſſen the ſollicitouſneſs of thy care for thine, nor make thee the leſs earneſt in the imploring and labouring for relief. In ſo depraved an age as ours, one may (and perhaps in vain too) ſearch hell to find wickeder men than are to be, but too frequently, met with upon earth: he will ſcarce be innocent, that will think himſelf ſo, as long as he finds a man more culpable than he; and he ſhall ſcarce ever judge himſelf guilty, whom the ſight of a guiltier will abſolve. Nor will that man (till it is perhaps too late) be apt to attempt an eſcape from the pollutions of the world, that ſtays till he can ſee none more inextricably intangled in them than himſelf. Do not, therefore, O my ſoul, content thyſelf with that poor comparative innocence, that in heaven (which it will never bring thee to) has no place, by reaſon of the abſence of all vicious perſons; and in hell itſelf (which it ſecures not from) can afford only the ill-natured conſolarion of not being altogether as miſerable, as the wretchedeſt perſon in that place of torment.

REFLECTION VI.

Sitting at eaſe in a coach, that went very faſt.

AS faſt as this coach goes, I ſit in it ſo much at eaſe, that whilſt its rapid motion makes others ſuſpect, that I am running for a wager, this lazy poſture, and this ſoft ſeat, do almoſt as much invite me to reſt, as if I were a-bed. The haſty wheels ſtrike fire out of the flints they happen to run over; and yet this ſelf-ſame ſwiftneſs of theſe wheels, which, were I under them, would make them cruſh my bones themſelves into ſplinters, if not into a jelly, now I am ſeated over them, and above their reach, ſerves but to carry me the faſter towards my journey's end. Juſt ſo it is with outward accidents, and conditions, whoſe reſtleſs viciſſitudes but too juſtly and too fitly reſemble them to wheels: when they meet with a ſpirit, that lies proſtrate on the ground, and falls groveling beneath them, they diſorder and oppreſs it; but he, whoſe high reaſon, and exalted piety, has, by a noble and ſteady contempt of them, placed him above them, may enjoy a happy and a ſettled quiet, in ſpite of all their buſy agitations; and be ſo far from reſenting any prejudicial diſcompoſure from theſe inferiour revolutions, that all thoſe changes, that are taken for the giddy turns of fortune's wheel, ſhall ſerve to approach him the faſter to the bleſt manſion he would arrive at.

REFLECTION VII.

Upon the ſight of a windmill ſtanding ſtill.

GENORIO, EUSEBIUS, LINDAMOR.

GEN. YOUR eyes, gentlemen have been ſo long fixed upon this windmill, that, in ſpite of the barrenneſs of the ſubject, I cannot but ſuſpect, it may have afforded one, or each of you, an occaſional meditation.

EUSEB. To juſtify your conjecture, *Genorio*, I will confeſs to you, that I was conſidering with myſelf, that if one, who knew not the miller's trade and deſign, ſhould look upon this ſtructure, he would think the owner worthy of ſo incommodious a manſion, if not of a room in *Bedlam*; for, we ſee, he has choſe to erect this fabrick in a ſolitary place, and upon the cold and bleak top of a ſwelling ground, where nothing ſhelters it from the violence of a wind, whilſt its high ſituation expoſes it to the ſucceſſive violences of them all. But he that is acquainted with the exigencies of the miller's deſign and trade, will think he has made a very proper choice, in ſeating himſelf in a place, where no wind can blow, that he ſhall not be able to make an advantage of. And having conſidered this, *Genorio*, my thoughts, when you interrupted them, were making this application of it; that we ought not to be too forward to cenſure men, otherwiſe virtuous, and diſcreet, for engaging themſelves, upon ſome accounts, to troubleſome and unſettling employments: for if the end be not miſchoſen, the means are to be eſtimated by their tendency thereunto; and though a calmer condition of life might be in itſelf more deſirable, yet when a more expoſed one can make him, that is qualified for ſuch employments, more ſerviceable in his generation, this may, upon that account, be more eligible than the other; ſince, as it expoſes him to more hardſhips, it affords him more opportunities of proſecuting his aims; ſo that his ſtation is recommended to him by thoſe very circumſtances, that make other men diſlike it.

GEN. But may not I alſo know what thoughts this worthy theme ſuggeſted to *Lindamor?*

LIND. I was, *Genorio*, taking notice, that this whole fabrick is indeed but a large engine, where almoſt every thing, as well as the ſails and the wheels, is framed and fitted for the grinding of corn: but, though this whole ſtructure be artificially enough contrived, yet it can now do nothing in order to its end, for want of ſuch a light and airy thing as a breath of wind, to put all this into motion. And, *Genorio*, this windmill, thus conſidered, brought into my mind the condition of a great lord, that you and I not long ſince viſited, and who

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who is far from being the only perſon; to whom the reflection may be applicable; for one, that not knowing his humour, and his aims, ſhould ſee how great a proviſion his plentiful fortune, and his ſkill to manage it, have laid together, of thoſe things, which are wont to be thought the chiefeſt inſtruments (and, perchance, the chief parts) of happineſs, would be apt to envy his condition, as diſcerning nothing that is wanting to it. But alas! the man expects and covets eſteem and reputation; and though fame have theſe reſemblances to the wind, that it is an airy and unſolid thing, which we muſt receive from others, and which we are not only unable to procure for our ſelves, but know not how long we ſhall keep it when we have it; yet the want of this alone makes all the reſt utterly inſufficient for his ſatisfaction. Thus the not ſo great as ambitious *Alexander*, after all the blood he had ſpilt in conquering the world, is ſaid to have ſhed tears, that he had conquered but one, when a philoſopher told him there were more. And all the favours, that the greateſt potentate upon earth could heap upon proud *Haman*, were, by his own confeſſion, unable to make him think himſelf happy, as long as he could not neglect a captive's neglect of him; all his greatneſs did him no good, if but one man had the courage not to bow to it; and an unſatisfied appetite of revenge quite ſpoiled the reliſh of the great monarch's favours, and the fair *Eſther*'s banquets. Nor do I doubt, *Genorio*, that we often marvel, if not repine, at providence, upon a great miſtake; for by refuſing to be God's ſervants, men uſually become ſo to their own unruly paſſions, and affections. And therefore we often very cauſeleſly envy the great and rich, as if they were as happy as the advantages vouchſafed them, would make a wiſe and good man; whereas perhaps the man courts a reputation, that is not be acquired by what men have, but by what they are, and do; or elſe he is in love with a lady, that loves not him, or loves another better: and the coyneſs of a miſtreſs, the greater title of a neighbour, or ſome ſuch trifling accident, that another would either not be ſubject to, or not be much concerned for, will keep him from enjoying any of thoſe very things, for which by-ſtanders envy him: ſo juſt it is, that in eſtimating a man's condition, we ſhould not only conſider what poſſeſſions he has, but what deſires.

REFLECTION VIII.

Upon his paring of a rare ſummer apple.

HOW prettily has curious nature painted this gaudy fruit? Here is a green, that emeralds cannot, and *Flora*'s ſelf might boaſt: and *Pomona* ſeems to have affected, in the freſh and lively vermilion that adorns this ſmooth rind, an emulation at rubies themſelves, and to have aimed at manifeſting, that ſhe can give her vegetable productions as lovely and orient, though not as laſting colours, as thoſe that make jewels precious ſtones; and if, upon the hearing the praiſes this ſcarlet deſerves, her bluſhes enoble her own cheeks with ſo vivid a colour, perhaps ſuch a livery of her modeſty might juſtify her pride. In a word, ſuch pure and tempting green and red dye this ſatine poliſhed ſkin, that our vulgar boldneſs muſt be no longer queſtioned, for rendring that fruit an apple, that inveigled our firſt parents. But though theſe winning dyes delight me ſtrangely, they are food for my eye alone, and not my ſtomach; I have no palate for colours; and to reliſh this fruit well, and know whether it performs to the taſte what it promiſes to the ſight, and juſtify that Platonick definition, which ſtyles beauty the luſtre and flower of goodneſs, all this gay outſide is cut and thrown away, and paſſes but for parings. Thus, in opinions, though I look with pleaſure on that neat faſhionable dreſs, that ſmoother pens ſo finely cloathe them with; and though I be delighted with the pretty and ſpruce expreſſions, that wit and eloquence are wont to trick them up with; yet when I mean to examine their true reliſh, that, upon liking, I may make them mine, I ſtill ſtrip and diveſt them of all thoſe flattering ornaments (or cheating diſguiſes rather) which ſo often conceal or miſrepreſent their true and genuine nature, and (before ever I ſwallow them) after they have been admitted by the more deluſible faculty we call fancy, I make them paſs the ſeverer ſcrutiny of reaſon.

REFLECTION IX.

Upon his coach's being ſtopt in a narrow lane.

HERE, for aught I can gueſs, my ſtay is like to be long enough, to afford me the leiſure of a reflection on it: for I have found already, in this narrow lane a very large ſcene to exerciſe my patience in; and this churliſh drayman ſeems reſolved to be as tedious to me, as *Ludgate-Hill* is to his horſe, when his cart is overloaden. They, that are going on foot to the ſame place this coach ſhould carry me to, find not their paſſage hindered, or their way obſtructed by that, which keeps me here; and were I diſpoſed to leave my coach behind, and foot it after them, I might in their company ſooner reach the place my deſigns and affairs call me to, than I ſhall (probably) be ſupplied with hopes of getting quickly out from hence. Alas! how frequently falls it out thus in our journeys towards heaven? Thoſe, whom their adverſe fortune, or a noble ſcorn, hath ſtript of, or releaſed from, theſe troubleſome and intangling externals, may tread the paths of life nimbly and chearfully, being unſtopt by many obſtacles, that intercept the progreſſes of others. But thoſe ſtately perſons, whoſe pride or effeminacy will not permit them to move an inch towards heaven, unleſs they may be carried thither in pleaſure's eaſy coaches, and who will not bate a ſuperfluity, or lay by the leaſt circumſtance or punctilio of grandeza, to leſſen themſelves into a capacity, of entering in at the ſtrait gate, may ſoon find theſe treacherous and over-loved conveniences turned into cumberſome clogs, and real impediments, that will, if not block up, at leaſt obſtruct the paſſage to the ſeat of ſo much joy; that even

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to be caſt aſhore there, by ſhipwreck, were a bleſſing; and that he is thought unworthy to be admitted there, that cannot think it his happineſs to reach that place himſelf, though he leave all behind him to get thither.

REFLECTION X.

Looking through a perſpective glaſs upon a veſſel we ſuſpected to give us chace, and to be a pirate. [*Sailing betwixt* Rotterdam *and* Graveſend *on* Eaſter-day, 1648.]

THIS glaſs does indeed approach the diſtruſted veſſel, but it approaches her only to our eyes, not to our ſhip; if ſhe be not making up to us, this harmleſs inſtrument will prove no loadſtone to draw her towards us; and if ſhe be, it will put us into a better readineſs to receive her. Such another inſtrument in relation to death is the meditation of it; (by mortals ſo much, and ſo cauſeleſly, abhorred:) for though moſt men as ſtudiouſly ſhun all thoughts of death, as if, like nice acquaintances, he would forbear to viſit, where he knows he is never thought of, or as if we could exempt ourſelves from being mortal, by forgetting that we are ſo; yet does this meditation bring death nearer to us, without at all leſſening the real diſtance betwixt us and him: if that laſt enemy be not yet approaching us, this innocent glaſs will no more quicken his pace, than direct his ſteps; and if he be, without haſtening his arrival, it will prepare us for his reception. For my part, my beardleſs chin allows me to preſume, that by the courſe of nature, I have yet a pretty ſtock of ſand in the upper part of my hour-glaſs: wherefore, though I am now too young to ſay with *Iſaac*, *Behold, now I am old, and I know not the day of my death*, Gen. xxvii. 2. yet ſince the youngeſt and luſtieſt of us all has cauſe to ſay with the mirror of patience, *When a few years are come, then ſhall I go the way whence I ſhall not return*, Job xvi. 22. and ſince it is the wiſe man's counſel, *Not to boaſt ourſelves of to-morrow, becauſe we know not what a day may bring forth:* I will endeavour (to uſe our Saviour's terms) *to take heed to myſelf, leſt at any time that day come upon me unawares*, Luke xxi. 34. And, as the only ſafe expedient in order thereunto, I will (in imitation of holy *Job*) *All the days of my appointed time, wait till my change come*, Job xiv. 24.

SECT. II.

Containing OCCASIONAL REFLECTIONS *upon the Accidents of an Ague.*

MEDITATION I.

Upon the firſt invaſion of the diſeaſe.

THIS viſit, dear * *Sophronia*, which you intended but for an act of kindneſs, proves alſo one of charity; for though it be not many hours ſince we parted, and though you left me free from any other diſcompoſure than that, which your leaving me is wont to give me; yet this little time has made ſo great a change in my condition, as to be, I doubt not, already viſible in my looks: for whilſt I was ſitting quietly in my chamber, and was as far from the thoughts of ſickneſs, as from any ſuch diſorders, as are wont to be the occaſions of it; and whilſt I was delightfully entertained by an outlandiſh virtuoſo, that came to viſit me, with an account of the ſeveral attempts, that are either made, or deſigned in foreign parts, to produce curioſities, and improve knowledge; I was ſuddenly ſurprized with a chilneſs, and a ſhivering, that came ſo unexpected, and increaſed ſo faſt, that it was heightned into a downright fit of an ague, before I could ſatisfy myſelf what it was. But I confeſs, that this unwelcome accident had not amazed me, as well as troubled me, if I had ſufficiently conſidered, to what a ſtrange number and variety of diſtempers theſe frail carcaſes of ours are obnoxious; for, if I had called to mind, what my curioſity for diſſections has ſhown me, and remembred how many bones, and muſcles, and veins, and arteries, and griſtles, and ligaments, and nerves, and membranes, and juices, a human body is made up of, I could not have been ſurprized, that ſo curious an engine, that conſiſts of ſo many pieces, whoſe harmony is requiſite to health, and whereof not any is ſuperfluous, nor ſcarce any inſenſible, ſhould have ſome or other of them out of order, it being no more ſtrange, that a man's body ſhould be ſubject to pain, or ſickneſs, than that an inſtrument with above a thouſand ſtrings (if there were any ſuch) ſhould frequently be out of tune; eſpecially ſince the bare change of air may as well diſcompoſe the body of a man, as untune ſome of the ſtrings of ſuch an inſtrument; ſo that even the inimitable ſtructure of human bodies is ſcarce more admirable, than that ſuch curious and elaborate engines can be ſo

* A Name often given by the Author to his excellent Siſter *R.* who was almoſt always with him, during his ſickneſs.

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ſo contrived, as not to be oftner out of order than they are; the preſervation of ſo nice and exact a frame being the next wonder to its workmanſhip. And indeed, when I conſider further, how many outward accidents are able to deſtroy the life, or, at the leaſt, the health, even of thoſe, that are careful to preſerve them; and how eaſily the beams of a warm ſun, or the breath of a cold wind, or too much, or too little exerciſe, a diſh of green fruit, or an infectious vapour, or even a ſudden fright, or ill news, are able to produce ſickneſs, and perhaps death; and when I think too how many evitable miſchiefs our own appetites, or vices, expoſe us to, by acts of intemperance, that neceſſitate the creatures to offend us, and practices of ſin, whereby we provoke the Creator to puniſh us: when, I ſay, I conſider all this, and conſequently how many miſchiefs he muſt eſcape that arrives at grey-hairs; I confeſs, the commonneſs of the ſight cannot keep me from thinking it worth ſome wonder, to ſee an old man, eſpecially if he be any thing healthy. But theſe kind of thoughts, *Sophronia*, are ſeldom entertained, unleſs they be excited by ſome unwelcome occaſions; and when we are long accuſtomed to health, we take it for granted, that we ſhall enjoy it, without taking it for a mercy that we are ſo: we are not ſenſible enough of our continual need and dependance on the divine goodneſs, if we long and uninterruptedly enjoy it; and by that unthankful heedleſſneſs we do, as it were, neceſſitate providence to deprive us of its wonted ſupports, to make us ſenſible, that we did enjoy, and that we always need them: it being but fit, that mercies ſhould ceaſe to be conſtant, which their conſtancy only, that ſhould be their indearment, keeps us from entertaining as mercies. I will therefore, *Sophronia*, endeavour to derive this advantage from this ſudden fit of ſickneſs, to make me thankful for health, when God ſhall be pleaſed to reſtore it me, and to keep me from reckoning confidently upon the laſtingneſs of it. For though we are very unapt to take even the wiſe man's counſel, where he forbids us to *boaſt ourſelves of to-morrow, becauſe we know not what a day may bring forth*; yet by ſuch accidents I find, that *Solomon* ſpoke much within compaſs, and had not done otherwiſe, if for a day he had ſubſtituted an hour: for ſo many, and ſo various are the unforeſeen accidents, to which we poor mortals are expoſed, that the continuance of our health or proſperity do much more merit our thanks, than the interruption of them can deſerve our wonder. And I muſt confeſs, *Sophronia*, that though my falling ſick may be but my unhappineſs, my being ſo much ſurprized at it was my fault.

MEDITATION II.

Upon the immoderate heat and cold of the aguiſh fit.

ONE that, not knowing what ails me, ſhould come in, and ſee me in this ſoft bed, not only covered, but almoſt oppreſſed with clothes, would confidently conclude, that, whether or no I be diſtreſſed by the contrary quality, I cannot at leaſt be troubled with cold; and if he himſelf were ſo, he will be apt to envy me. And if, inſtead of coming in my cold fit, he ſhould viſit me in my hot one, and ſee me with my ſhoulders and arms quite uncovered, and nothing but the ſingle ſheet on the reſt of my body; he would be apt to think, that I muſt lie very cool. But alas! in ſpite of all that lies upon me, an internal froſt has ſo diffuſed it ſelf through every part, that my teeth chatter, and my whole body does ſhake ſtrongly enough to make the bed it ſelf do ſo; and, though I ſtill wiſh for more clothes, yet thoſe, that are heaped on me, can ſo little controul this preternatural cold, that a pile of them might ſooner be made great enough to cruſh, than to warm me: ſo that when I travelled even in froſty nights, the winter had nothing near ſo ſtrong an operation on me. And as that external cold was far more ſupportable whilſt it laſted, ſo it was incomparably more eaſy for me, by exerciſe, and otherwiſe, to deliver my ſelf from it.

THUS, when a great or rich man's mind is diſtempered with ambition, avarice, or any immoderate affection, though the by-ſtanders, that ſee not what diſquiets him, but ſee what great ſtore of accommodations fortune has provided for him, may be drawn to envy his condition, and be kept very far from ſuſpecting, that he can want that contentment, the means of which they ſee him ſo richly ſupplied with: and yet alas! as the colder heat of the external air is much leſs troubleſome to a man in health, though furniſhed with an ordinary proportion of clothes, than the cold or hot fit of an ague, with a pile of blankets firſt, and then a ſingle ſheet; ſo to a vigorous and healthy conſtitution of mind, external inconveniences are much more ſupportable, than any accommodations can make the condition of a diſtemper'd ſoul. Let us not then judge of men's happineſs, ſo much by what they have, as by what they are; and conſider both, that fortune can but give *much*, and it muſt be the mind, that makes that much *enough*: and that, as it is more eaſy to endure winter, or the dog-days in the air, than in the blood; ſo a healthful mind, in ſpite of outward inconveniences, may afford a man a condition preferable to all external accommodations without that.

MEDITATION III.

Upon the ſucceſſion of the cold and hot fit.

WHEN the cold fit firſt ſeized me, methought it was rather melted ſnow than blood, that circulated in my veins, where it moved ſo inordinately, and maintained the vital flame ſo penuriouſly, that the greateſt ſign, which was left to diſtinguiſh this cold from that of death, was its making me ſhake ſtrong enough to ſhake the bed I lay on. I called for more and more clothes, only becauſe I needed them, not becauſe I found any relief by them: I fancied the torrid zone to be of a far more deſirable conſtitution than that we call the temperate;

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perate; and as little as I am wont to reverence vulgar chymiſts, I then envied their laborants, whoſe imployment requires them to attend the fire. But when the cold fit was once over, it was quickly ſucceeded by a hot one, which after a while I thought more troubleſome than it. I threw off the clothes much faſter than my former importunity had procured them to be laid on me; and I, that could a little before ſcarce feel all that had been heaped on me, could not now ſupport a ſingle ſheet, but thought its weight oppreſſed me.

I ENVIED the inhabitants of *Norway*, and *Iceland*, far more than thoſe, that dwell either in the richeſt province of *Eaſt-India*, or of the Golden Coaſt it ſelf: and of all creatures, not rational, I thought the fiſhes the happieſt, ſince they live in a cool ſtream, and, when they pleaſe, may drink as much as they liſt.

IF then, *Sophronia*, the ſelf-ſame perſon may, within leſs than two hours, have ſuch different apprehenſions of his own condition, as now to complain of that as a ſad grievance, which but an hour before he wiſhed for as a relief; we may well acknowledge, that we frequently miſtake in eſtimating the hardſhips and afflictions we complain of, and find them not ſo uneaſy as we make them, whilſt we not only endure the whole affliction, that troubles us, but often increaſe it, by repining at the envied condition of others.

AN afflicted man is very apt to fancy, that any kind of ſickneſs, that for the preſent troubles him, is far leſs ſupportable, than if it were exchanged for another diſeaſe; and imagines his caſe to be ſo ſingular, that one cannot ſay to him in St. *Paul*'s language, *No temptation has befallen you, but that which is common to men*, 1 Cor. x. 13. He preſumes, that he could far more eaſily ſupport his croſſes, if inſtead of his preſent diſeaſe, he had this or that other; though, if the exchange were made, he would, perchance, wiſh for his firſt ſickneſs, if not be as much troubled at his own folly, as with the diſeaſe. He that is tormented with the gout, is apt to envy any ſick man, that is exempted from that roaring pain, and able to walk about: he that is ſwelled with the dropſy, fancies all perſons happy, whoſe diſeaſes allow them drink to quench their thirſt: and the blind man envies both theſe, and thinks no perſons ſo miſerable in this world, as thoſe that cannot ſee the world. Fevers burn us, agues ſhatter us, dropſies drown us, phrenſies unman us, the gout tortures us, convulſions wrack us, epilepſies fell us, colicks tear us; and in ſhort, there is no conſiderable diſeaſe that is not very troubleſome in it ſelf, however religion may ſanctify and ſweeten it: for as a fortreſs, whoſe defendants are not treacherous, can ſcarce be taken otherwiſe than either by famine, or ſtorm; ſo life, for whoſe preſervation nature is ſo faithfully ſollicitous, cannot be extinguiſhed, unleſs either chronical diſeaſes do lingeringly deſtroy, or ſome acute do haſtily ſnatch it away. And indeed, if a diſeaſe prove mortal, it is no more than is to be expected, if it tire out the patient with tedious languiſhments, or elſe diſpatch him with diſmal ſymptoms: nor is it in point of ſickneſs only, that we are often more unhappy than we need, by fancying ourſelves more unhappy than we ſhould be, if we were allowed to exchange that, which now troubles us, for any thing which does not. But there are evils, which, though exceeding contrary in appearance and circumſtances, do yet agree in being extremely troubleſome; as the poſſeſt wretch our Saviour cured in the Goſpel, though he were ſometimes caſt into the fire, and ſometimes into the water, yet in both ſtates was tormented by the ſame devil, who, in variety of inflictions, ſtill expreſſed the ſame malice. But we ſhould make a righter eſtimate of ſuffering, if we did but conſider, that much uneaſineſs is annexed to an afflicted condition in general; and that therefore, which we are ſenſible of, may proceed rather from the general nature of ſickneſſes, and croſſes, than from the particular kind and degree of ours. And indeed, if a man were permitted to exchange his diſeaſe with thoſe of others, he would often find his granted wiſhes to bring him a variety of miſchiefs, rather than an exemption from them; and many of thoſe, that we envy, as thinking them far leſs ſufferers than our ſelves, do look with invidious eyes on us, and do but diſſemble their grievances more handſomely than we, not find them more eaſy than ours. And that of St. *Peter* may be more generally applied, than moſt men think, where he exhorts to conſtancy, upon this conſideration, *That the ſame ſufferings are accompliſhed upon our brethren in the world*, 1 Pet. v. 9. For it is all one as to the efficacy of this lenity, whether our afflictions be the ſame with thoſe of others, in kind, or not ſuperiour to them in degree: and I doubt not, but we ſhould ſupport many of our grievances as eaſily as thoſe, for which we wiſh them exchanged, if the chief account, upon which they trouble us, were not rather, that they are the preſent ones, than the greateſt.

MEDITATION IV.

Upon the being let blood.

ONE of the moſt troubleſome ſymptoms in almoſt all feveriſh diſtempers is wont to be thirſt; and in mine it was importunate to a degree, that made me very much ſo, in frequently ſolliciting thoſe, that were about me for drink, which, in the heat of the fit, ſeemed ſo deſirable an object, that it then much leſſened my wonder at that parch'd king's agreement, who, urged with thirſt, ſold his liberty for a full draught of cold water. But alas! I ſadly found, that the liquor I ſwallowed ſo greedily, afforded me but a very tranſient relief, the latter being gone almoſt as ſoon as the former had paſſed thorough my throat; ſo that not only it did but amuſe me, not cure me; but, which is worſe, drinking it ſelf increaſed my thirſt, by increaſing the fever, whoſe uneaſy ſymptom that was. Wherefore, ſeeing all the cooling juleps that could be adminiſtered, did free me from nothing but the expectation of being much relieved by ſuch ſlight and palliative

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liative medicines; the doctor thought himſelf this day obliged to a quite contrary, and yet a more generous remedy; and ordered, that, inſtead of giving me drink, they ſhould take away blood, as judging it the beſt and far the ſureſt courſe to take away the uneaſy ſymptoms, by removing that, which foments the cauſe.

THUS when the mind is diſtempered with turbulent commotions, and the diſquieted appetites does too reſtleſsly and eagerly crave objects, which, though perhaps in themſelves not abſolutely bad, are at leaſt made, by a conjunction of circumſtances, unfit and dangerous for the perſon that longs for them: we, like unſkilful or unruly patients, fondly imagine, that the only way to appeaſe our deſires is, to grant them the objects they ſo paſſionately tend to. But the wiſe and ſovereign phyſician of ſouls, who conſiders not ſo much what we do wiſh, as what we ſhould wiſh, often diſcerns, that this præternatural thirſt indicates and calls for a lancet, rather than a julep, and knows it beſt to attempt the cure, rather by taking away ſomewhat that we have, than by giving us that, which only a ſpiritual ſuperfluity reduces us to want. And in effect, we often ſee, that as a few ounces of blood taken away in a fever do cool the patient more than the giving him ten times as much drink would do; ſo a few afflictions, by partly letting out, and partly moderating our corrupt affections, do more compoſe and appeaſe a mind moleſted with inordinate appetites, than the poſſeſſion of a great many of the objects we impotently deſire. Whilſt our appetites are roving, and unreaſonable, and inſatiate, the obtaining of this or that particular object does but amuſe the patient, not take away the diſeaſe; whereas ſeaſonable and ſanctified croſſes, that teach us to know our ſelves, and make us ſenſible how little we deſerve, and how little the things we are ſo greedy of could make us happy, if obtained, may reduce us to a reſignation, and tranquillity of mind, preferable to thoſe over-valued things, which, as it keeps us from enjoying, ſo it keeps us from needing. Thus *Zacheus*, who, whilſt a publican, never thought he had enough, when he had once entertained our Saviour, though he offered to make a quadruple reſtitution of whatever he had fraudulently acquired, was, upon a ſudden, by being freed from avarice, grown ſo rich, that he was, forward to give no leſs than half he had to the poor; as if his divine gueſt had wrought upon his goods ſuch miracles, as he had done upon the five loaves, and two fiſhes, of which the remains amounted to more than the whole proviſion was at firſt.

MEDITATION V.

Upon the taking of phyſick.

THE laſt bitter potion that I took, *Sophronia*, was, I remember, ſweetned with the hopes were given me with it, that it might prove the laſt I ſhould need to take, and would procure me a ſettled and durable health: but I find by ſad experience, that the benefit I derived from it is nothing near ſo laſting as it was welcome; for I am now reduced to take phyſick again, and I fear muſt often do ſo, before I ſhall be able to diſlodge this troubleſome ague that haunts me. For though the laſt phyſick I took, wrought ſo well, that I hoped it had brought away not only the ill-humours themſelves, but the very ſources of them; yet by the effect of what I took this morning, I not only find there is as much to be purged away now, as there was then, but, what is ſadder, I can ſcarce hope this phyſick will excuſe me from the need of taking more again ere long. But though it is a troubleſome thing, and muſt be often repeated, yet it is a ſalutary thing too, and cannot be more unpleaſant than it is uſeful; and as loathſome as it is, a ſickneſs were far worſe. Thus when a relenting ſinner has endeavoured to waſh away his ſins with his tears, he may poſſibly think himſelf ſo thoroughly waſhed in that abſterſive brine, (which yet owes its cleanſing virtue not to its own nature, but to the blood of Chriſt) that if he be a new convert, and be entertained with thoſe raviſhing delights, wherewith God is often pleaſed to engage ſuch returning prodigals, (as the kind father welcomed his riotous ſon with feaſting, and with muſick) that he is apt to fancy repentance to be like baptiſm, which, being received once for a man's whole life, needs never be renewed. But though, during ſuch tranſports, an unexperienced convert may be apt to caſt the gauntlet to the world, ſaying in his ſpiritual proſperity, that he ſhould never be moved; yet, as our Saviour ſpeaks, *The ſpirit indeed is willing, but the fleſh is weak*: and too commonly our reſolutions flag with our joys, and thoſe that a while before imagined they deſpiſed the world, find themſelves worſted, if not captivated, by it; and find it far more difficult than they thought it, to live in the company of ſinners without being of their number, and in ſo defiled a world without being ſpotted by it.

AND as the ſame *David*, who ſaid in his proſperity, he ſhould never be moved, ſaid in his diſtreſs, he ſhould one day periſh by the hand of *Saul*; ſo many of thoſe, that whilſt their tears of repentance, and of joy, are not yet dried off their eyes, are apt to defy and contemn all the ghoſtly enemies, and difficulties, that oppoſe their preſent zealous reſolutions, will, perhaps, in a while after, when they meet with unexpected impediments, and foils, change their confidence into deſpair, and think thoſe very enemies, whom they lately looked on as deſpicable, to be inſuperable. But as phyſick, that does good for a time, ought not to be rejected, becauſe it does good but for a time; nor ſhould we reject the only ſure means of our preſent recovery, for fear of future relapſes: ſo, though we ſadly find, that repentance muſt be repeated, and that after we have practiſed it often, we muſt have need of it again; yet ſince it is the only proper means to recover a ſoul out of a ſtate of ſin, which is

worſe than any diſeaſe, and leads to the worſt of deaths, we muſt never ſuffer our ſelves to be ſo far diſcouraged, as to forego ſo neceſſary and ſo profitable a duty, and muſt not more frequently relapſe into faults, than renew our ſorrow for them, and our reſolves againſt them: for innocence indeed is far more deſirable than repentance, as health is than phyſick. But as phyſick is more eligible than the continuance of ſickneſs, ſo is repentance more eligible than continuing in the ſtate of ſin: and as the drinking even of a bitter potion is a leſs evil than the heat, and thirſt, and reſtleſſneſs of an ague; ſo to lament for ſin here, is a far leſs uneaſy thing, than to do it in a place, where there is nothing but remedileſs wailing, and gnaſhing of teeth. It is true, that our ſouls are in this too like our bodies, that our whole lives are ſpent betwixt purging away of naughty humours, and accumulating them: and methinks, I hear the fleſh ſtill ſaying unto the ſpirit, as *Ruth* did to *Naomi*, *the Lord do ſo to me, and more alſo, if aught but death part thee and me*, Ruth i. 14. But although there are defilements, which, though often waſhed off, will as often come again to blemiſh us; and though the *deeds of the* * *body* will ſcarce all of them perfectly be put to death, but with the body it ſelf; yet next to an uninterrupted ſtate of health, frequent and early recoveries are deſirable: and though the ſhameful neceſſity of needing to beg many pardons for the ſame fault may juſtly make an ingenuous Chriſtian cry out with Saint *Paul*, *O wretched man that I am! who ſhall deliver me from the body of this death?* yet the ſame ſenſe of his own frailty, that puts this exclamation into his mouth, may comfort his heart, by its being a pledge, that he ſhall one day be able exultingly to ſay with the ſame Apoſtle in another place, *Thanks be to God, which giveth us the victory, through our Lord Jeſus Chriſt*, 1 Cor. xv. 57.

Rom. viii. 13.
* Θανατόω.

MEDITATION VI.

Upon the ſyrups and other ſweet things ſent him by the Doctor.

THIS complaiſant phyſician, *Sophronia*, is, you ſee very ſollicitous, that his remedies ſhould as well gratify the patient, as oppoſe the diſeaſe: and beſides that this julip is ting'd with ſyrup of clove-july-flowers, that it may at once delight the palate, and the eye; ſome of theſe other remedies are ſweetned with as much ſugar, as if they came not from an apothecary's ſhop, but a confectioner's. But my mouth is too much out of taſte to reliſh any thing, that paſſes through it; and though my ſickneſs makes this flattering of the palate almoſt neceſſary to the rendring theſe medicines takable by me, yet upon the account of the ſame diſtemper, all that the Doctor's tenderneſs and ſkill could do to make them *pleaſant*, can at moſt but keep them from being *loathſome*. And therefore you will eaſily believe, *Sophronia*, that I enjoy theſe ſweet things upon a ſcore, that, if it does imbitter them, does at leaſt, as to me, deprive them of their nature: ſo that he, that, for the ſake of theſe ſyrups and electuaries, ſhould, notwithſtanding the malady that needs them, envy me, might be ſuſpected to be troubled with a worſe diſeaſe than an ague is, a frenzy.

THUS there are many favourites of fortune, whoſe ſeeming enjoyments may, perchance, be envied by thoſe, that do but gaze on their condition, whilſt it is rather pitied by thoſe that know it. To be brought by greatneſs of power, or riches and effeminacy of mind, to that paſs, that they ſeldom hear any thing but their own praiſes, even when their actions merit reprehenſion, and that they can reliſh nothing that is not ſweetned with ſo much of flattery, as quite to diſguiſe, and perhaps pervert, its nature: theſe, as I was going to ſay, and ſuch other unhappy privileges, are things, which (whatever fools may think) will not recommend greatneſs to a conſidering man, and are far more fit to procure the poſſeſſor's ruin, than wiſe men's envy: and beſides that a vain and impotent ſoul is, by thoſe diſquieting qualities, moleſted with greater diſtempers, than thoſe gratifications can make amends for, and which often hinder the full reliſhing of theſe or any other pleaſures. The delight theſe treacherous delicacies afford, is ſo much leſs conſiderable than the weakneſs they ſuppoſe; that it is far more eligible to be without them than to need them.

MEDITATION VII.

Upon the want of ſleep.

AH! dear *Sophronia*, in ſpite of all the care and officiouſneſs of thoſe diligent attendants, that you were pleaſed to ſend to watch with me, I have ſlept all night as little as I do now, or as I ſhall deſire to do whilſt you ſtay here.

THIS unwelcome leiſure brought me as much a neceſſity, as an opportunity to ſpend the time in entertaining my thoughts, which on this occaſion were almoſt as various, and ſeemed too as wild, as, if I had ſlept, my dreams themſelves would have been: and therefore, I preſume you will not wonder, if I can now recall but few of them, and if the reſt be as eaſily vaniſhed out of my memory, as they came abruptly into my mind.

THE firſt thought, that I remember entertained me, was that, which was the moſt naturally ſuggeſted by the condition I was in: for when I found how tedious and weariſome each hour was, and obſerved how long a time ſeemed to intervene betwixt the ſeveral diviſions, that the ſtriking of the clock made of a night, that muſt at this time of the year be much ſhorter than the day; I could not but conſider, how inſupportable their condition muſt be, to be caſt into outer darkneſs, where tormented wretches lie, not as I do upon a ſoft bed, but upon fire and brimſtone, where no attendance of ſervants, or kindneſs of friends, is allowed them, that need it as much as they deſerve it little; and, which is worſt of all, where

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where no beam of hope is permitted to conſolate them, as if the day ſhould dawn after ſo diſmal a night, though protracted to millions of ages, each of whoſe miſerable hours appears an age.

THE next thing I was conſidering, was, how defective we are in point of gratitude to God: I now bluſh, that I cannot call to mind the time, when I ever thought, that his having vouchſafed me the power of ſleeping deſerved a particular acknowledgment. But now I begin to ſee, that it is our heedleſſneſs, not their uſeleſſneſs, that keeps us from daily being thankful for a multitude of mercies, that we take notice of; though it be injurious, that that only commonneſs, that heightens the benefit, ſhould keep us from us from being ſenſible of the greatneſs of it. I confeſs I was very lately one of them, who looked upon ſleep as one of thoſe inconveniencies of human nature, that merit a conſolation; and I very little apprehended, that I ſhould ever complain of the want of ſleep, as of a grievance, the neceſſity of it being what I always looked upon under that notion. But I now perceive, he was a wiſe man, who ſaid, *That God made every thing beautiful in its ſeaſon.* And yet, when I conſider the affinity betwixt ſleep and death, whoſe image it is, I cannot but think it very unlikely, that this life ſhould be deſigned for our happineſs, ſince not to loſe almoſt half of it were an infelicity.

ANOTHER thing I remember I was conſidering, was this, that though want of ſleep be one of the uneaſieſt accidents, that attend on ſickneſs, yet in many caſes it proves as uſeful as it can be unwelcome. For there is a ſort of jolly people, far more numerous than I could wiſh them, who are at utter defiance with thinking, and do as much fear to be alone, as they ſhould to do any courſe, that is naturally productive of ſo unmanly a fear: and the ſame ſinful employments, or vain paſtimes, that make them afraid of being alone, do ſo much keep them from the neceſſity of being ſo, that they keep them almoſt from the very poſſibility of it. For in the time of health, viſits, buſineſſes, cards, and I know not how many other avocations, which they juſtly ſtyle diverſions, do ſucceed one another ſo thick, that in the day there is no time left for the diſtracted perſon to converſe with his own thoughts: and even, when they are ſick, though they be debarred of many of thoſe wonted diverſions, yet cards and company will give them enough to prove a charm againſt thinking, which the patient is ſo willing, or rather ſollicitous, to decline, the need of that ſickneſs leſs troubles him, as it keeps his body from going abroad, than as it tends to drive his thoughts home; ſo that ſickneſs does little or nothing towards the making ſuch men conſider, by caſting them upon their beds, unleſs it alſo hinder them from ſleeping there. But in the long and tedious nights, when all the praters, and the gameſters (who are uſually called good companions, but ſeldom prove good friends) are withdrawn, and have left our patient quite alone, the darkneſs of the night begins to make him diſcern, and take ſome notice of his own condition, and his eyes, for want of outward objects, are turned inwards, he muſt, whether he will or no, during the ſilence of the night, hear thoſe leſſons, which by the hurry and avocations of the day he endeavoured to avoid. And though this be a very unwelcome mercy, yet it is a mercy ſtill, and perhaps the greater for being ſo unwelcome: for if he could ſleep in ſickneſs, as he uſed to do in health, he were in great danger of having his conſcience laid aſleep, till it ſhould be awaked by the flames and ſhrieks of hell. And the deſign of God in chaſtening being to reclaim and amend us, we not only do, by our want of reflecting, endure the trouble of ſickneſs, without reaping the benefit of it; but alſo by our ſhunning to conſider, we are ſo ill-natured to our ſelves, as to lengthen the ſickneſs, we are ſo impatient of; which is in us as fooliſh, as it would be in a nice patient, after having been made to take a bitter, but a ſalutary potion, to ſend unſeaſonably for cordials and juleps to hinder the working of it, and ſo by ſuch unrulineſs loſe the benefit of the operation, and lengthen his pain and ſickneſs, to avoid the far leſs trouble of complying with the nature of the medicine, and the deſigns of the phyſician: ſo that repentance being neceſſary to recovery, and the conſidering of a man's own ways as neceſſary to repentance, the want of ſleep, which both allows us time, and impoſes on us a neceſſity to think, may well be looked upon as a happy grievance, ſince it very much tends to the ſhortning of our afflictions, by the diſpoſing us to co-operate towards God's aims in ſending them.

MEDITATION VIII.

Upon telling the ſtrokes of an ill-going clock in the night.

THE ſame violence of my fit, that made me very much need ſleep, allowed me ſo little of it, that I think I miſs'd not hearing one ſtroke of the clock all the night long. But ſince you know, *Sophronia*, that the clock is kept by the ſoldiers, that are quartered in the place where it ſtands, you will eaſily believe, that it is not very carefully looked to; eſpecially ſince they are not only wont to let it go ill, but do oft times make it do ſo on purpoſe, and as may beſt comply with the officers occaſions, and as they would have the guards, that are to be ſet here, or to be ſent hence, ſooner or later relieved. Of this uncertain going of the clock I never had occaſion to take ſo much notice as the laſt night, when, lying too conſtantly awaked, I began to obſerve, that though all the hours were ſo tedious, as to ſeem every one of them extraordinarily long, yet they manifeſtly appeared to me not to be equally ſo; and therefore, when the clock ſtruck eleven, to ſatisfy my ſelf, whether it did not miſ-inform me, I called to one that ſat up by me for the watch I uſe to meaſure the time with in nice experiments, and found it to want but very little of midnight; and not much above an hour after, when by my watch it was but about one, thoſe that

that kept the clock, whether out of negligence, or deſign, or to make amends for paſt ſlowneſs, made it ſtrike two; which ſeemed to me to hint a not unuſeful rule in eſtimating the length or ſhortneſs of diſcourſes: for there are caſes, where the difficulty or importance of the ſubject is ſuch, that though it coſt a man many words, yet if what he ſays be not ſufficiently fitted to the exigency of the occaſion, and the theme, he may ſpeak much, without ſaying enough. But on the other hand, if (as it often happens) a man ſpeak either unſeaſonably, erroneouſly, or impertinently, he may, though he ſay little, talk too much; the paucity or number of words is not, as many think it, that, which is in ſuch caſes to be chiefly conſidered; for it is not many, or few, that are required, but enough. And, as our clock ſtruck not ſo often as it ſhould have done, when it ſtruck eleven, and yet ſtruck a while after too often when it ſtruck but two, becauſe the firſt time it was midnight, and the ſecond time it was but one of the clock; ſo to eſtimate, whether what is ſaid have its due length, we are not ſo much to look, whether it be little, or much, or whether a man ſpeak in the right time, and ſay neither more nor leſs than he ſhould.

MEDITATION IX.

Upon comparing the clock and his watch.

THE occaſion I had, *Sophronia*, to compare the clock and my watch, ſuggeſted to me this other reflection, that the dial-plate of the clock being I know not how many times larger than that of the watch, the circle, on which the hours were marked in the one, did by vaſt odds exceed the correſpondent circle of the other: and yet, though the index of the clock had then paſt through a far greater quantity of ſpace than that of the watch, this little index, being, when it was indeed midnight, arrived at the mark of the twelfth hour, when the greater index was come but to that of the eleventh, I juſtly concluded, that the watch did only go truer, but more forward than the clock.

THUS in eſtimating men's lives, there is ſomething elſe to be looked at than the mere duration of them; for there are ſome men, who having loitered and trifled away very many years in the world, have no other argument of their age, than the church-books of their grey-hairs; and as little do they indeed live, that waſte a number of inſignificant years in ſucceſſive or perpetual diverſions from the true buſineſs and end of life. Theſe, and many other kind of perſons, that conſume much time to little purpoſe, may be ſaid rather to have laſted long, than to have lived long: as the careleſs wanderer, who, inſtead of travelling, does nothing but ſtray from one wrong way to another, though he do ſo at midſummer, from morning to night, may be ſaid to have been long on horſe-back, but not to have performed a long journey: whereas he, that by thrifty huſbanding his time, and induſtriouſly improving it, has early diſpatched the buſineſs, for which he was ſent into the world, needs not grey-hairs, to be reputed to have lived long enough, and conſequently longer than thoſe, that wear grey-hairs, only becauſe they were born many years before him. In a word, to one of thoſe ſort of men we may attribute a longer time, but to the other a longer life; (for even the Heathen could ſay, *Non eſt vivere, ſed valere vita)* and within how narrow a compaſs ſoever a man's life be confined, if he have lived ſo long, as, before he comes to the end of life, he have reached the ends of living; the attainment of that meaſure of knowledge, and the practice of thoſe graces and virtues, that fit a man to glorify God in this ſhort life, and to be glorified by him in that which ſhall have no end.

MEDITATION X.

Upon a thief in a candle.

THE ſilence of the night, and my being unable to ſleep, diſpoſing me to have my attention very eaſily excited; I chanced to take notice, that the dim light of thee candle, which the curtains were not drawn ſo cloſe as to exclude every where out of the bed, was on a ſudden conſiderably increaſed, and continued ſo long in that condition, that, for fear of ſome miſchance, I put my head out of the bed to ſee, whence it was that this new and unexpected increaſe of light proceeded; but I quickly found, that it was from a thief (as they call it) in the candle, which by its irregular way of making the flame blaze, had melted down a good part of the tallow, and would have ſpoiled the reſt, if I had not called to one of thoſe, that watched with me, to reſcue the remains by the removal of the thief. But I had ſcarce done this, when, I confeſs to you, *Sophronia*, I found my ſelf invited to make ſome reflections upon what I had done, and to read my ſelf a new leſſon by the beams of this new light. For though this thief made the candle ſhine more ſtrongly, and diffuſe a much greater light than it did before; yet becauſe it made a great and irregular waſte of the candle, I ordered it to be taken away; and on this occaſion methought I might juſtly make uſe of that ſaying of *Pharaoh*'s forgetful butler, *I do remember my faults this day*: For though I find no great difficulty in abſtaining from other kinds of intemperance, yet to that of ſtudying, my friends, and eſpecially my phyſicians, have often accuſed me of being too indulgent. Nor can I altogether deny, but that in mental exerciſes there can be exorbitancies, and exceſſes, I may have ſometimes been guilty of them; and that the things, for which I think life valuable, being the ſatisfaction, that accrues from the improvement of knowledge, and the exerciſe of piety, I thought it allowable, if not commendable, to conſume or hazard it for the attainment of thoſe ends; and eſteemed ſickneſs more formidable for its unfitting me to learn, and to teach, than for its being attended with pain and danger; and looked upon what it made me forbear, as far more troubleſome than

Gen. xli. 9.

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whatever elſe it made me endure. But I find my body is a jade, and tires under my mind, and a few hours fixed contemplation does ſenſibly ſo ſpend my ſpirits, as to make me feel my ſelf more weary than the riding poſt for twice as many hours has ever done. Wherefore, ſince, though the proper uſe of a candle be to conſume it ſelf, that it may give others light, I yet thought it fit to have the thief taken away, becauſe, though it made the candle give more light, it would have waſted it too faſt, and conſequently made it expire too ſoon. I ſee not how I can reſiſt their perſuaſions, that would have me huſband better the little ſtock of ſtrength nature has given me; and the rather, by a moderate expence of it, endeavour to make it ſhine longer, though but dimly, than conſume it too faſt, though for a while to keep up a blaze: I will therefore endeavour to learn of this ſickneſs, and of this accident, what the doctors hitherto could never teach me, and enjoin my ſelf an abſtinence, which to me is more uneaſy, than if wine, or women, or other ſenſual pleaſures were to be the objects of it; but if in ſo difficult an exerciſe of ſelf-denial, I do not always perform what I am now perſuaded to, it is like I ſhall eaſily forgive my ſelf, for but a little haſtening the end of my life to attain the ends of it.

MEDITATION XI.

Upon the being in danger of death.

I KNOW, that phyſicians are wont, after their maſter *Hippocrates*, to tell us, that fevers which intermit are devoid of danger. But though an ague, whilſt it continues ſuch, could not be a mortal diſeaſe; yet why may it not degenerate into ſuch a one? And for my part, who take the prognoſticks of phyſicians to be but gueſſes, not prophecies, and know how backward they are to bid us fear, till our condition leave them little hopes of us; I cannot but think that patient very ill adviſed, who thinks it not time to entertain thoughts of death, as long as his doctor allows him any hopes of life: for in caſe they ſhould both be deceived, it would be much eaſier for the miſtaken phyſician to ſave his credit, than for the unprepared ſinner to ſave his ſoul.

WHEREFORE, *Sophronia*, finding my diſeaſe attended with unuſual threatening ſymptoms, not knowing where they would end, I laſt night thought it fit to ſuppoſe they might end in death: and two things eſpecially made me the more ready for ſuch an entertainment of my thoughts.

ONE, That we can ſcarce be too careful and diligent in fitting our ſelves for the acting of a part well, that we can never act but once: for where the ſcripture tells us, *it is appointed for all men once to die*; it is immediately ſubjoined, that *after that comes judgment*; and if we die ill once, we ſhall never be allowed to die again, to ſee if we would die better the ſecond time than we did the firſt: but as the wiſe man allegorically ſpeaks, *Where the tree falls, there ſhall it lie.* So that the faults committed in this laſt and importanteſt of human actions, being irreparable, I think the only ſafe way is to imitate him, who, having ſaid, *If a man die, ſhall he live again?* preſently annexed by way of inference and reſolution, *All the days of my appointed time will I wait till my change come.*

THE other conſideration, that recommended to me the thoughts of the grave, was this, that we may be often ſollicitous to provide againſt many evils and dangers, that poſſibly may never reach us; and many endure, from the anxious fears of contingent miſchiefs, that never will befall them, more torment, than the apprehended miſchiefs themſelves, though really ſuffered, would inflict. But death will ſooner or later infallibly come, and never finally deceive our expectations; and therefore the fore-thoughts of it are an employment, which may prove, we know not how ſoon, of uſe, and will (however) prove of excellent advantage: the frequent meditation of the end of our lives, conducing ſo much to make us lead them well, that the expectation of death brings not leſs advantages to thoſe that eſcape the grave, than thoſe that deſcend into it.

SUCH like conſiderations, *Sophronia*, having put me upon the thoughts of death, I preſume you may have ſome curioſity to know what theſe thoughts were; and therefore, though I have neither fitneſs, nor inclination to mention to you thoſe, that almoſt every ſober perſon would have upon a death-bed, as a man, and as a Chriſtian, I will only take notice to you of thoſe few, that were ſuggeſted to me, by the leſs general circumſtances of my condition. And I am the more willing to ſatisfy your curioſity now, becauſe I have my ſelf been very inquiſitive on the like occaſion: for the approach of death will (if any thing can) make men ſerious and conſiderate; being for good and all to go off the ſtage, they make a truer and ſincerer judgment of the world they are ready to leave, and then have not the wonted partiality for the pleaſures and profits of a life they are now abandoning. And as the mind looks with other eyes upon the world, when death is ready to ſhut thoſe of the body; ſo men are then wont as well to ſpeak their thoughts more frankly, as to have them better grounded: death ſtripping moſt men of their diſſimulation, as well as of other things it makes them part with; and indeed it is then high time for the ſoul to put off her diſguiſes, when ſhe is ready to put off the very body it ſelf.

ONE thing then, that I was conſidering, *Sophronia*, was, in how wretched a condition I ſhould now be, if I had been of the ſame mind with the generality of thoſe, who are of the ſame age with me: for theſe preſume, that youth is as well made for pleaſures as capable of them, and is not more a temptation to vanity, than an excuſe for it. They imagine themſelves to do a great matter, if, whilſt youth laſts, they do ſo much as reſolve to grow better when it is gone; and they think, that for a man to be otherwiſe than intentionally religious before his hair begin to change colour, were not only to loſe the privileges of youth,

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but to incroach upon thoſe of old age. But alas! how few are deſtroyed by that incurable diſeaſe, in compariſon to thoſe that die before they attain it? And how little comfort is it upon a death-bed, to think, that by the courſe of nature, a man might have lived longer, when that very thought might juſtly prove diſmal to an unprepared man, by ſuggeſting to him, that this early death may argue the meaſure of his iniquities exceeding great, and that this untimely end is not ſo much a debt due to nature, as a puniſhment of ſin? All the fruition of theſe deluding pleaſures of ſin cannot countervail the horror, that a dying man's review of them will create, who not only ſees himſelf upon the point of leaving them for ever, but of ſuffering for them as long. And on the contrary, the review of youthful pleaſures declined for virtue's or religion's ſake will afford a dying man far higher joys, than their fruition would ever have afforded him.

MEDITATION XII.

Upon the ſame ſubject.

AND one thing more there is, *Sophronia*, that I dare not conceal from you, how much cauſe ſoever I have to bluſh at the diſcloſing it; and it is, that I judge quite otherwiſe of a competent preparation for death now I am near it, than I did when I was in health. And therefore, if one, that, ſince his conſcience was firſt thoroughly awakened, ſtill reſolved to be a Chriſtian, and though he too often broke thoſe good reſolutions, never renounced them, but tripped and ſtumbled in the way to heaven, without quitting his purpoſe of continuing in it, finds a formidableneſs in the approach of death; how uncomfortable muſt that approach be to thoſe, that have ſtill run on in the ways of ſin, without once ſo much as ſeriouſly intending to forſake them? A youth free from ſcandal, and ſometimes productive of practices, that were ſomewhat more than negative piety, is not ſo frequent among thoſe, that want not opportunities to enjoy the vanities and pleaſures of the world, but that the charity of others being ſeconded by that great inward flatterer ſelf-love, made me imagine, that I was in a condition fitter to wiſh for death, than to fear it. But now I come to look on death near at hand, and ſee beyond the grave, that is juſt under me, that bottomleſs gulph of eternity; methinks it is a very hard thing to be ſufficiently prepared for a change, that will tranſmit us to the bar of an omniſcient judge, to be there doomed to an endleſs ſtate of infinite happineſs or miſery. There is no art of memory like a death-bed's review of one's life; ſickneſs, and a nearer proſpect of death, often makes a man remember thoſe actions, wherein youth and jollity made him forget his duty; and thoſe frivolous arguments, which when he was in health, and free from danger, were able to excuſe him to his own indulgent thoughts, he himſelf will ſcarce now think valid enough to excuſe him unto God, before whom, if the ſinleſs angels cover their faces, ſinful mortals may juſtly tremble to be brought to appear. When the approach of death makes the bodily eyes grow dim, thoſe of the conſcience are enabled to diſcern, that as to many of the pleas we formerly acquieſced in, it was the prevalence of our ſenſes, that made us think them reaſon: and none of that jolly company, whoſe examples prevailed with us to join with them in a courſe of vanity, will ſtand by us at the bar to excuſe the actions they tempted us to. And if they were there, they would be ſo far from being able to juſtify us, that they would be condemned themſelves. It is true, *Sophronia*, if we conſider death only as the concluſion of life, and a debt all men ſooner or later pay to nature; not only a Chriſtian, but a man, may entertain it without horror: but if one conſider it as a change, that after having left his body to rot in the grave, will bring his ſoul to the tribunal of God, to anſwer the miſcarriages of his whole paſt life, and receive there an unalterable ſentence that will doom him to endleſs and inconceivable joys, or everlaſting and inexpreſſible torments; I think it is not inconſiſtent either with piety or courage, to look upon ſo great a change with ſomething of commotion: and many, that would not fear to be put out of the world, will apprehend to be let into eternity.

MEDITATION XIII.

A further continuation.

ANOTHER thing, *Sophronia*, which my preſent ſtate ſuggeſted to me, was a reflection on the great miſtake of thoſe, that think a death-bed the fitteſt and opportuneſt place to begin repentance in: but ſure theſe men are very little acquainted, either with the diſadvantages of a dangerous ſickneſs, or the nature of repentance. It is true, that ſin and death do more eaſily frighten one, when they are looked on as both together; but I much doubt, whether the being frighted by hell be ſufficient to give a man a well-grounded hope of heaven: for when we ſee ſin and torment at one view, and ſo near one to another, it is not ſo eaſy to be ſure, which of the two it is, that, as we preſume, ſcares the ſinner towards heaven. And ſurely repentance, which ought to be the change of the whole man, and in ſome ſenſe the work of the whole life, is very improperly begun, when men have finiſhed that courſe, which it ſhould have guided them in: nor have men cauſe to preſume, that when God is ſeverely puniſhing them for their ſins, he will vouchſafe them ſo great a grace as that of repentance, which they would none of, till it could not make them ſerviceable to him. And as for the opportunity, it is hoped an expiring ſtate may give men for repentance, they muſt needs be great ſtrangers to great ſickneſſes, that can promiſe themſelves ſo unlikely a matter. Who can ſecure them, that the acuteneſs of the diſeaſe will not invade the brain? And as deliriums and phrenſies are not unfrequent in fevers, and other acute diſeaſes; ſo in caſe they happen to perſevere, the wretched patient is caſt into a deſperate condition, even on this ſide the grave, and

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and as near as the body is to its diſſolution, the man may be dead a pretty while before it.

But ſuppoſing he eſcape theſe accidents, which make repentance impoſſible, a dangerous ſickneſs has other circumſtances enough to make it very uneaſy: for the organical faculties of the mind cannot but be dulled and prejudiced by the diſcompoſure of the ſpirits, by which their functions are to be exerciſed; and the ſenſe of pain, the troubleſome preſcriptions of phyſicians, the loathſome and bitter potions, the weakening operation of phyſick, the languiſhments produced by want of ſpirits, the reſtleſſneſs proceeding from heat and want of ſleep, the diſtracting importunity of thoſe intereſted perſons, eſpecially if any of them be ſuſpected to hover about the dying man's bed, as birds of prey, that wait for a carcaſe; the ſighs and tears of friends and relations, that come to take their laſt farewell, and to imbitter it; the lawyer, that muſt be directed to draw up the will; the divine, that muſt be allowed to ſay ſomething concerning the ſoul; and the affrighted conſcience, that alone brings more diſquiet than all the reſt put together; do make a dying man's condition ſo amazing, ſo diſmal, and ſo diſtracting, that to think this an opportune time to begin ſuch a work, (which may well enough imploy the whole man in his calmeſt ſtate of mind) is a madneſs as great as any, that even a death-bed can, by the tranſlation of the humours into the brain, occaſion. For my part, I think it ſo wild, and ſo unadviſable a thing to put off the beginning to provide all graces to a death-bed, that I think it uneaſy enough ſo much as to exerciſe *then* thoſe that were acquired *before*; men being in that ſtate commonly unable ſo much as to reap the conſolation they have been ſowing all along a pious life.

And this, *Sophronia*, brings into my mind a conſideration, which being taken from the very nature of a death-bed repentance, ſhould, methinks, very much deter men from reſolving beforehand to rely on it; and it is this, that granting thoſe (Socinians, and others) to be miſtaken, that think ſo late a repentance to come too late to be available; yet the dying ſinner, though he may be kept from deſpair of paſſing to heaven, can ſcarce in an ordinary way have a comfortable aſſurance of getting thither; for though it be ſaid, that a true repentance cannot come too late, yet it is a hard thing to be certain, that ſo late a repentance is true. Since repentance confeſſedly importeth an abandoning and renouncing of ſin, at leaſt in hearty purpoſe and reſolution; it is very difficult for an habitual ſinner, that remembers what vows and purpoſes of change of life, ſickneſſes or dangers have formerly induced him to make, which were forgotten, or violated, when the apprehenſions that occaſioned them were over; it is hard, I ſay, for ſuch a one to be ſure, that his preſent repentance is not of the ſame ignoble and uncurrent kind, ſince he has no experience to ſatisfy him, that it would be ordinarily, though not conſtantly, prevalent over the oppoſite temptations; and ſince alſo (which is mainly to be conſidered) it is ſo eaſy for a man to miſtake for the true hatred of ſin, and the love of God, a horror of ſin ſpringing from the preſent painful ſenſe of the miſchief procured by it, together with the great fear of the approaching torments that it threatens, and a ſtrong deſire of going to heaven, when ſeeing himſelf unable to ſtay any longer on earth, he muſt get thither to eſcape hell. And as it is thus difficult, when a man already feels much puniſhment for ſin, and ſees himſelf in danger of more, to diſcern clearly upon what account it is, that he is ſorry for what he has committed; ſo it muſt be certainly a ſtate unſpeakably anxious and uncomfortable to find one's ſelf dragged to the grave, without knowing, whether the laſt trumpet ſhall call him thence to heaven, or to hell. And if he ſhould be deceived in judging of the validity of his repentance, the fatal error would be remedileſs, and the miſtake far ſadder and more horrid than that of the Syrians, who, when they thought they were arrived victorious at *Dothan*, found themſelves at the mercy of their enemies in *Samaria*, 2 Kings vi. 18. To conclude, *Sophronia*, he, that reſolves not to renounce his ſins, till he thinks Chriſt ready to renounce him for them, may very probably loſe his ſoul, and has moſt certainly loſt his ingenuity; and that will appear a very ſad loſs for a man, that being by death denied the opportunities of actually leading a new and pious life, muſt derive his comfort from the aſſurance, that he ſincerely intends it.

MEDITATION XIV.

Upon the apprehenſions of a relapſe.

I HAVE now at length, *Euſebia*, by the goodneſs of God, regained that meaſure of health, which makes the doctor allow me to return to my former ſtudies, and recreations, and diet; and in a word, to my wonted courſe of life: ſo that the phyſician having diſmiſſed himſelf, nothing ſeems more ſeaſonable and pertinent to my preſent condition, than that of our Saviour to the paralytick man, to whom he gave both recovery, and an admonition, which, if he obeyed, he found the more advantageous of the two; *Behold, thou art made whole; ſin no more, leſt a worſe thing come unto thee.* But I am not ſo free from the apprehenſions of an ague, as my friends think me from the danger of it: for having ſadly experienced the uneaſineſs of ſickneſs, I am thereby brought, though at no eaſy rate, to ſet a high value upon health, and be a very jealous preſerver of ſo great a bleſſing; and thoſe petty chilneſſes, that formerly I regarded not, but was apt to impute to nothing but fumes of the ſpleen, or melancholy vapours, are now able to give me hot alarms, and make me apt to fancy them the fore-runners, if not the beginners, of the cold fit of an ague, the firſt invaſion of that diſeaſe having been preceded by the like diſtempers; and accordingly, I carefully avoid the leaſt irregularities in point of diet, or of any other kind, that may any ways endanger a relapſe into the

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diſeaſe, that once handled me ſo ill. But why ſhould I be more apprehenſive for my body than my mind? and if at any time (as it may but too often happen) any ſin ſhould come to be prevalent in my mind, why ſhould I not be ſollicitouſly afraid of all the occaſions and approaches of it, and tremble at theſe commotions of the appetite, which would not elſe perhaps be formidable to me, in caſe I have found that ſuch beginnings indulged or neglected have ended in actual ſin, the real diſeaſe of the ſoul? And as dangerous ſickneſſes do for the moſt part leave a crazy diſpoſition behind them, which threatens relapſes; ſo ſins once prevalent, though afterwards ſuppreſt, do yet leave behind them a ſecret diſpoſition or propenſity to the reception of the ſame faults. And as it is leſs difficult to find examples of bodily diſeaſes, than of ſpiritual ones, where the patient is protected from relapſes; ſo I think we ſhould be more watchful againſt falling back into the ſins, than into the ſickneſſes, we have once found our ſelves ſubject to, unleſs we ſhould think, that a greater danger, and of a nobler part, deſerved leſs of our care.

MEDITATION XV.

Upon his reviewing and tacking together the ſeveral bills, filed up in the apothecary's ſhop.

EITHER my curioſity, *Sophronia*, or my value of health, has made it my cuſtom, when I have paſſed through a courſe of phyſick, to review the particulars it conſiſted of; that taking notice by what remedies I found moſt good, and by what, little or none; if I ſhould fall into the like diſtemper for the future, I might derive ſome advantage from my paſt experience. In compliance with this cuſtom, as I was this day reviewing and puting together the doctor's ſeveral preſcriptions ſent me back by the apothecary; good God! ſaid I, in my ſelf, what a multitude of unpleaſant medicines have I been ordered to take! the very numbering, and reading them, were able to diſcompoſe me, and make me almoſt ſick, though the taking of them helped to make me well. And certainly, if when I was about to enter into a courſe of phyſick, all theſe loathſome medicines, and uneaſy preſcriptions, had been preſented to me together, as things I muſt take, and comply with, I ſhould have utterly deſpaired of a recovery, that muſt be ſo obtained, and ſhould not perhaps have undertaken ſo difficult and tedious a work, out of an apprehenſion, that it would prove impoſſible for me to go thorough with it. Thus when a man conſiders the duties, and the mortifications, that are requiſite to a recovery out of a ſtate of ſin into a ſtate of grace, he muſt be reſolute enough, if he be not deterred from undertaking the conditions, that piety requires, by ſo many and great difficulties, as will preſent themſelves to his affrighted imagination. But let not this make him deſpondent; for it is true, that theſe diſcompoſing medicines, if I muſt have taken ſo much as a tenth part of them in one day, would have either diſpatched me, or diſabled me to endure the taking any the next. But then, although I now ſee theſe troubleſome preſcriptions all at once, I did not uſe them ſo, but took only one or two harſh remedies in one day, and thereby was enabled to bear them, eſpecially being aſſiſted by moderate intervals of reſpite, and ſupported both by other ſeaſonable cordials, and by that higheſt cordial, the hope, that the uſe of theſe troubleſome means of recovery would ſoon free me from the need of them. And thus, though the hardſhips of piety are, by the ghoſtly and carnal enemies of it, wont to be repreſented to one that begins to grow a convert, ſo great and formidable a multitude as to be inſuperable; yet if he conſiders, that though his foreſight meet with them all at once, yet he will need to grapple with them but one after another, and may be as well able to overcome a temptation this day, or to-morrow, as he did another yeſterday: ſo that to this caſe alſo may in ſome ſenſe be applied that (either counſel, or precept) of our Saviour, not to be ſollicitous for to-morrow, but to charge no more upon a day than the trouble that belongs to it. And if he conſiders too, that as a wiſe phyſician has always a great care, that his remedies be not diſproportionate to the patient's ſtrength, and after harſh phyſick to relieve him with cordials; ſo God will not ſuffer thoſe, that intruſt themſelves to him, to be tempted above what they are able, but will allow them cordials after their ſufferings, in caſe he do not turn the ſufferings themſelves into cordials. If, I ſay, our new convert ſhall conſider things of this nature, he will not be much diſcouraged by the appearance of difficulties, that will as much enoble and indear his ſucceſs, as they can oppoſe it; and he will never deſpair of victory in an engagement, where he may juſtly hope to have God for his ſecond, and heaven for his reward.

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OCCASIONAL REFLECTIONS.

SECT. III.

REFLECTION I.

Upon the ſight of ſome variouſly-coloured clouds.

THERE is amongſt us a ſort of vain and flanting grandees, who for their own unhappineſs, and their age's, do but too much reſemble theſe painted clouds; for both the one and the other are elevated to a ſtation, that makes moſt men look upon them, as far above them; and their conſpicuouſneſs is often increaſed by the bright ſunſhine of the prince's favour, which, though it really leaves them creatures of the ſame frail nature, that it found them of, does yet give them a luſtre and a gaudineſs, that much attracts the eye, and perhaps the envy and reſpect of thoſe ſuperficial gazers upon things, that are wont to be amuſed, if not dazzled, with their inſignificant outſides. But the parallel holds further; for as, in ſpite of theſe clouds' ſublimity and conſpicuouſneſs, they are but airy and unſolid things, conſiſting of vapours, and ſteered by every wind: ſo the fine people I am comparing them to, in ſpite of their exaltation, and of all the ſhew they make, are really but ſlight perſons, deſtitute of intrinſick and ſolid worth, and guided either by their own blind luſts and paſſions, or elſe by intereſts as fickle as thoſe, (to which it will be no addition to ſay) or as variable as the wind. And as theſe clouds, though they ſeem vaſt as well as high, and are perhaps able, for a while, to make the ſky ſomewhat dark, have uſually but a ſhort duration, and either quickly fall down in rain, or are quite diſſipated, and made to diſappear; ſo thoſe titled perſons, what ſhew ſoever their greatneſs makes, do oftentimes, either by a voluntary humility and repentance, as it were, deſcend of their own accord, and, by doing of good, endeavour to expiate and make amends for their former uſeleſſneſs, if not miſchiefs; or elſe, after having been a while ſtared at, they do (ſome of them more ſlowly, and ſome more abruptly) vaniſh, without leaving behind them any thing that can ſo much as entertain our ſight in the very place, where before they engroſſed it: and this ruin ſometimes happens to the moſt elevated perſons, from that very prince, whoſe favour made them attract ſo many eyes; as clouds are oftentimes diſperſed before night by the ſame ſun, that had raiſed and gilded them in the morning.

REFLECTION II.

Upon his making of a fire.

HOW many fruitleſs blaſts have I been ſpending upon this ſullen fire! It was not, though, the greenneſs of this wood, that made it ſo uneaſy to be kindled; but, it was alone the greatneſs of the logs, on which the fire could take no hold, but by the intervention of ſuch ſmaller ſticks as were at firſt wanting here: witneſs, that I had no ſooner laid on a little bruſhwood, but the flame from thoſe kindled twigs, invading and prevailing on the billets, grew ſuddenly great enough to threaten to make the houſe it ſelf part of its fuel, and turn it to ſuch aſhes, as it makes haſte to reduce the wood into. Methinks the blaze of this fire ſhould light me to diſcern ſomething inſtructive in it: theſe blocks may repreſent our neceſſary; theſe ſticks our leſs important, religious practices; and this aſpiring flame, the ſubtile inhabiter of that of hell. It will be but ſucceſsleſly, that the devil can attempt our grand reſolves, till he have firſt maſtered our leſs conſiderable ones; and made his ſucceſſes againſt theſe, not only degrees, but inſtruments, in the deſtroying of the other: our more neglected and ſeemingly trivial affections, having once received his fiery impreſſions, do eaſily impart them to higher faculties, and ſerve to kindle ſolider materials. It is therefore the ſafeſt way, to be faithful even to our leſſer determinations, and watchful over our leſs predominant paſſions; and whenſoever we find our ſelves tempted to violate the former, or neglect the latter, not ſo barely to caſt one eye upon the ſeeming inconſiderableneſs of what we are inticed to, as not to fix the other upon the conſequences that may attend it; and therein, to conſider the importance of what ſuch ſlighted things may, as they are managed, prove inſtrumental, either to endanger, or to preſerve.

REFLECTION III.

Upon my ſpaniel's carefulneſs not to loſe me in a ſtrange place.

DURING my ſtay at home, whilſt every body this cur chanced to meet, made ſo much of their landlord's ſpaniel, that they ſeemed to have added to oracles that proverb of *Love me, love my dog*, the cajolled cur would never keep at home; but being welcomed to ſo many places abroad, made me few viſits, that coſt me not the trouble of ſending for him. But now, that we are in a place, where he ſees no more men than ſtrangers, he ſtirs not from my heels, and waits ſo cloſe, and carefully, that it were now more difficult to loſe him, than it was formerly to keep him from wandering. Thus doth it generally fare with us; whilſt we are environed with numerous outward objects, which, ſmiling on us, give our gaddings to them, the temptation of an inviting welcome; how inclined are we to forget and wander from our great maſter? But when we are deprived of thoſe enveigling courters, our Maker too is freed from thoſe ſeducing rivals, and our undiſtracted affections are

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brought to ſettle on their nobleſt object, by the removal, and the diſplacing, as well as they would be by the knowledge and the undervaluation, of inferiour ones. Lord! when I loſe a friend, or any outward idol of my fondneſs, teach me to reduce him to leave thee his heir, by taking that loſs for a ſummons, to transfer and ſettle my whole love on thee: and if thou but vouchſafe to make me ſo happy, I ſhall think my ſelf enough ſo, not to envy him, to whom the loſs of his aſſes proved an occaſion of his finding a crown; and ſhall not ſo much regret what thy diſpenſations ſhall have taken from me, as gratulate to my ſelf their having reduced me unto thee.

REFLECTION IV.

Upon the prodigiouſly wet weather, which happened the ſummer that Colcheſter *was beſieged.* (1648.)

HOW ſtrangely unſeaſonable is this melancholy weather! and how tedious a winter have we endured this ſummer? More than theſe few laſt weeks have not afforded us half as many days, wherein we were neither troubled with ſhowery, or threatened by cloudy weather; and we in *England* have great temptations to envy nature's kindneſs unto *Rhodes* *, if it be true what geographers relate of that iſland, that it is a rarity for the inhabitants to ſee a day paſs without their ſeeing the ſun: for, among us, the confuſions of our country ſeem to have infected our very air, and ſerenity is as great a rarity in the ſky, as in men's conſciences; ſo that thoſe, who are wont to make fires, not againſt winter, but againſt cold, have generally diſplaced the florid, and the verdant ornaments of their chimneys, and think *Vulcan* more proper there than *Flora*; and ſome begin to doubt, whether our almanacks be not miſtaken, by calling this month *July* inſtead of *November*. But notwithſtanding all this appearance of winter above our heads, yet whilſt we ſee, that cherries and ſtrawberries, and other ſummer fruits, do grow, and, though but ſlowly, make a progreſs towards maturity in our orchards, we doubt not that it is ſummer, and expect, that theſe fruits, though they will not be early ones, will at length come to be ripe ones.

THUS, for reaſons, which, though we know not yet, our knowing of God may aſſure us to be both wiſe, and juſt, a pious ſoul may ſometimes be reduced to ſo ſad a condition, that the face of heaven does to her appear perpetually overcaſt; and the tokens of God's diſpleaſure do ſo cloſely follow one another, that, to borrow *Solomon*'s phraſe, *The clouds return after the rain.* But if, notwithſtanding all this, the ſeemingly deſerted ſoul, do, like the good ground mentioned in the goſpel, bring forth fruit with perſeverance; if prayer, charity, reſignation, and thoſe other divine graces, that are wont to be the proper and genuine productions of God's ſpirit, do flouriſh, and proſper in the ſoul, we may ſafely conclude that ſoul, though never ſo diſconſolate, to be in the ſtate of grace, and that ſhe really receives the bleſt aſſiſtances of him, who can alone give the increaſe (to the ſeeds of piety and virtue) though not in the glad and conſpicuous way of an unclouded heaven, yet in the effectual, though ſecret, method of fructifying influences; and we may reaſonably hope, that he, that has not only begun a good work, but carried it on thorough ſuch impediments, and diſadvantages, will perfect it, by bringing the ſlow, but yet gradually, ripening fruit to the due perfection: for thoſe, that are the humble Chriſtian's proper graces, do ſo much depend upon the author, that, if they flouriſh, his hiding himſelf in clouds need not make us doubt the fruits we ſee, to be the productions of the Sun of righteouſneſs, though we ſee him not. We muſt not haſtily conclude it winter with the ſoul, though the heaven be lowering, provided the earth be fruitful; but remember, that the ſaving influence of God's ſpirit may be, where his comfortable preſence is not perceived: the living in ſenſible comforts and joys is rather a part of our reward, than of our duty; and that (conſequently) it may ſave many modeſt and pious perſons a great deal of diſquiet, if they would learn to judge of their ſpiritual condition, rather by the duties, and ſervices, they pay God, than by the preſent conſolations he vouchſafes them; or, in a word, rather by what they do, than by what they feel.

REFLECTION V.

Upon his being carved to at a feaſt.

THOROUGH many hands hath this plate paſſed, before it came to mine; and yet, though I bowed to every one of thoſe that helped to convey it, I kept my chief and ſolemneſt acknowledgment for the fair lady that ſent it. Why ſhouldeſt thou not, O my ſoul, inſtruct thy gratitude to tread in the ſteps of thy civility? When thou receiveſt any bleſſing from *that Father of lights, from whom every good and perfect gift comes down*, pay a fitting ſhare of thy thanks to them, that hand it to thee; but thorough all thoſe means, look principally to that God, that ſends it. Let not the pipe uſurp upon the ſpring, (that were as abſurd, as it were for me to kiſs my hand to the plate, or at beſt, to thoſe that helped to convey it, with a neglect of the lady) but ſo pay thy due acknowledgments to the reachers, that thou be ſure to reſerve thy principal thanks, and higheſt ſtrains of gratitude, for the giver.

REFLECTION VI.

Upon the ſight of a looking-glaſs, with a rich frame.

EUGENIUS, LINDAMOR, EUSEBIUS.

Lind. THIS glaſs has a frame ſo curious, and ſo rich, that though I could ſcarce, if I would, withhold my eyes from gazing here; yet, I believe, the operation it has

* At *Rhodes* the Air is never ſo dim and cloudy, but one hour or other the ſun ſhineth out. *Pliny, l.* 2. *c.* 62. Where he alſo ſays the ſame of *Syracuſa.*

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has on my curioſity, is no more than what it generally has on that of others; and by the attention, with which I ſaw, even you, gentlemen, ſurvey it, I am eaſily perſuaded, that one needs not be a lady, not to paſs by ſuch a looking-glaſs without repairing to it.

Eug. I AM much of your opinion, *Lindamor*; and ſuch a ſight as this has often made me a greater friend, than many ſeverer perſons are, to eloquence in ſermons: for as if this very glaſs had been placed here in a mean or common frame, it would ſcarce have ſtopped us in our paſſage through the room, or have invited us to conſult it; ſo a ſermon may, by the nicer ſort of auditors, be left unregarded, though it be for ſubſtance excellent: when as the frame, though it be not part of the glaſs, nor ſhews us any part of our faces, does yet, by its curious workmanſhip, attract our eyes, and ſo invite us to conſult the glaſs, that is held forth in it; ſo the wit, and fine language, wherein it is dreſſed up, though it be no eſſential or theological part of the ſermon, yet it is often that, which invites men to hear, or read it.

Lind. I THINK indeed, *Eugenius*, that wit and eloquence do highly recommend ſermons, and devout compoſures, to the curioſity and attention of ſome, that elſe would ſcarcely mind them; and upon that account, I allow of your compariſon: but give me leave to carry it on a little further, by obſerving, that as the curious frame doth as well pleaſe, as attract, the eye, without repreſenting to it the lively image of the beholder's face; ſo the fine expreſſions you applaud, are commonly parts of a ſermon, that have no ſpecular virtue in them; I mean, that have no power, like a good looking-glaſs, to acquaint the beholder with the true image or repreſentation of his own complexion, and features: nor will this gaudy frame ſhew him what is otherwiſe than it ſhould be; the diſcovery of which, nevertheleſs, in order to the rectifying what is amiſs, is the principal and genuine uſe of a looking-glaſs. And therefore, as no ſkilful man will judge of the goodneſs of a glaſs, by the fineneſs of the frame, but rather by its giving him a true repreſentation of his face, without liking it the worſe, for ſhewing him its moles, and warts, or other blemiſhes, if it have any; ſo no wiſe Chriſtian will judge of a rouſing ſermon, rather by the language, than the divinity, or will think the worſe of a good book, for diſcovering his faults, or making him think the worſe of his own, or other men's ill courſes.

Euſeb. LET me add, gentlemen, that as when a glaſs has a rich and gaudy frame, children's eyes are oftentimes ſo entertained and amuſed with it, that they are regardleſs of any thing elſe; and for the ſake of that part, which they can but ſee, they are unmindful to conſult that uſefuller part, whoſe office it is to diſcover to them, themſelves: ſo, when there is too much of rhetorick in a ſermon, many, that ſhould not be children, have attention, not only ſo attracted, but ſo detained, by that, that they are not thereby invited to conſult, but diverted from regarding, the more inſtructive part of the diſcourſe. And the more witty and critical ſort of auditors, are ſo much more accuſtomed to judge of ſermons, than to judge of themſelves by them, that they deal with them, as if, in this glaſs, a man ſhould only praiſe or diſcommend the workmanſhip of the imboſſed images of the frame, without caring to make uſe of the glaſs itſelf, to mend any thing he finds out of order about him. For thus, theſe faſtidious and cenſorious hearers make no other uſe nor repetition of ſermons, than to cenſure or applaud the expreſſions, and contrivances, (which ſhould be looked upon but as the ornaments of it) without minding the doctrine, or caring to amend what that has diſcovered to be amiſs in them. But it muſt be confeſt, though I muſt grieve and bluſh, it can be truly ſo, that it is but too often, as the ſcripture ſomewhere complains, *like people, like prieſt*; and that there is a ſort of preachers, and thoſe of the moſt celebrated, who take a courſe more likely to encourage, than reform, ſuch hearers; and which would, perhaps, make men ſuch, if it did not find them ſo: for one of this ſort of preachers (for I am loth to call them divines) appears more ſollicitous to make his expreſſions, than to make his hearers, good. And whereas, theſe, that are concerned for the winning or the ſaving of the ſouls, think it a leſs ſure ſign of a good ſermon, that it makes the hearers applaud the preacher, than that it makes them condmn themſelves; the orator I am mentioning, had much rather hear their praiſes than their ſighs; and, accordingly, is more ſollicitous to tickle their ears, than, how much need ſoever there be of it, to launce their conſciences. He may, with far more truth than piety, invert the profeſſion of St. *Paul*, and ſay, that he preaches *not Chriſt crucified, but himſelf*; and though now and then he ſeem very vehemently to declaim againſt vices, yet one may eaſily enough perceive, that it is but a perſonated anger, and that he rather fences with ſin, than is concerned to deſtroy it, and ſpeaks againſt it rather to ſhew ſkill, than to exerciſe hatred: and as he affects to appear rather an orator than a divine, ſo he is well enough content his auditors ſhould rather admire his good language than follow his beſt counſel; and, as if all that belongs to miniſters, and their flocks, could be performed in the pulpit, and the pew, he is more careful to remember his ſermons before he has delivered them, than to keep his auditors from forgetting them afterwards; and unconcerned for their proficiency, ſeeks but their praiſes, ſcarce ever aiming at ſo much as his own diſcharge. In a word, in ſuch kind of ſermons, there is little ſpoken, either from the heart, or to the heart; the orator and the auditory tacitly agreeing to deceive themſelves; and the converſion of ſinners being neither the effect, nor the aim of ſuch florid, but unedifying diſcourſes, the buſineſs is tranſacted on both ſides, as if the preacher thought he had done his part, when he had ſhewn his wit, and the hearers thought they had done theirs, when they have commended it.

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REFLECTION VII.

Upon my ſpaniel's fetching me my glove.

POOR cur! how importunate is he to be imployed about bringing me this glove? and with what clamours, and how many fawnings, does he court me to fling it him? I never ſaw him ſo eager for a piece of meat, as I find him for a glove: and yet he knows it is no food for him, nor is it hunger, that creates his longings for it; for now I have caſt it him, he does nothing with it, but (with a kind of pride to be ſent for it, and a ſatisfaction, which his glad geſtures make appear ſo great, that the very uſe of ſpeech would not enable him to expreſs it better) brings it me back again; as he meant to ſhew me, he deſired not to keep it for himſelf, but only to have it in his power to return it as a preſent to his maſter. But he muſt not bring me thus an empty glove; it is in thee, my ſoul, to fill this accident with inſtruction, by learning from religion as diſintereſted a behaviour towards God, as nature taught this brute creature towards me. I will, in my addreſſes for externals, leſs earneſtly implore them for the ſervice they may do me, than for the ſervice I may do God with them; and (as princes commands are looked upon by courtiers as honours, and as favours) contenting myſelf with the ſatisfaction of being truſted, and imployed by him, I will rejoice at the liberal expreſſions of his love, as they may be improved into proportionable expreſſions of mine, and will beg no largeſs of his bounty, without a deſign of referring it to his glory.

REFLECTION VIII.

Upon the taking up his horſes from graſs, and giving them oats before they were to be ridden a journey.

JUST ſo does God uſually deal with his ſervants: when he vouchſafes them extraordinary meaſures of grace, they are to look for employments that will exerciſe it, or temptations that will try it.

THUS that great *captain of our ſalvation*, Heb. xii. 2. whom the ſcripture ſo much and ſo deſervedly exhorts us to have our eyes on, when at his ſolemn inauguration into his prophetick office, the heavens were opened, from whence the ſpirit of God did in a bodily ſhape deſcend like a dove upon him, accompanied with a heavenly voice, proclaiming him the beloved ſon of God, *in whom the Father is well pleaſed*, *Matth.* iv. *Then*, I ſay, that is, (as St. *Mark* tells us) *immediately* Jeſus (*being*, as ano- Mark i. 12. evangeliſt has it, *full of the Holy Ghoſt*, Luke vi. 1) was led *up of the ſpirit into the wilderneſs to be tempted of the devil.* That wiſe and merciful diſpoſer of all things, who will not *ſuffer his children to be tempted above what they are able*, ſeaſonably fortifies them by theſe preparatory proviſions and conſolations, for the labours and difficulties they are to be expoſed to. But whereas, if theſe horſes had reaſon wherewith to foreſee the journey in order whereunto the provender is ſo plentifully given them, they would (if not be troubled at their good cheer) at leaſt loſe much of the pleaſure of it, by thinking of the labour to enſue. With the ſervants of God the caſe is much otherwiſe; for ſuch is his goodneſs to thoſe he is pleaſed thus to deal with, in propoſing and reſerving them a crown in ſome ſort proportionate to, and yet ineſtimably outvaluing, the toils and difficulties requiſite to obtain it; that as advantageous and as welcome as his preparatory vouchſafements can be, the pious ſoul may well think them leſs favours upon their own account, than as they enable the receiver to do the more ſervice to the giver.

REFLECTION IX.

Upon the making of a fire with charcoal.

THOSE that luſt faſcinates are apt to imagine, that if they can ſuppreſs its viſible effects, and ſenſible heat, that will be ſufficient to free them from all the miſchiefs, they need fear from it: but luſt is ſo pernicious a gueſt, that not only he is very watchful to intrude again where he has once been entertained, but, notwithſtanding his abſence, he may continue to do miſchief to thoſe, that ſeem to have quite expelled him. For as wood, that is once thoroughly ſet on fire, may afterwards have that fire quite choaked, and extinguiſhed, and yet by thoſe changes be turned into charcoal, whereby it is not only made black, but diſpoſed to be far more eaſily kindled, and conſumed than before; ſo thoſe, who have once had their hearts thoroughly poſſeſt by the pernicious flames of luſt, (which is indeed, to imploy an inſpired expreſſion, *to be ſet on fire of hell*) even when they have ſtifled theſe criminal flames, and feel no more of their heat, may not only have their reputation irrecoverably blemiſhed by what is paſt, but commonly carry about with them an unhappy diſpoſition to be re-inflamed, and to have by a few ſparks, and a little blowing, thoſe deſtructive fires ſo re-kindled, as to rage more fatally than ever.

REFLECTION X.

Looking through a priſmatical or triangular glaſs.

THIS more than flattering glaſs adorns all the objects I look on through it, with a variety of colours, whoſe vividneſs does as much charm my ſenſe, as their nature poſes my reaſon; without the help of the ſun, and clouds, it affords me as many rainbows as I pleaſe. And not only when I look on trees, and meadows, and gardens, and ſuch other objects, that are of themſelves acceptable to the ſight; this glaſs lends them ornaments above any they are beholden for either to nature, or art; but when I caſt my eyes upon coarſer, and homely things, and even on dunghills, this favourable interpoſer preſents them to me in ſuch curious and gaudy coloars, that it does not ſo properly hide their deformities, as to make them appear lovely.

So

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So that which way ſoever I turn my eyes, I find them ſaluted, as if I were in ſome rich jeweller's ſhop, with ſaphires, topazes, emeralds, and other Orient gems, the vividneſs of whoſe colours may juſtify thoſe, that think colours to be but diſguiſed light, which, by theſe various reflections, and refractions, comes to be rather dyed than ſtained.

BUT this glaſs muſt as well afford me inſtruction, as delight, and even by deceiving me, teach me: for thus ſinful Chriſtians, when God looks upon them in themſelves, muſt needs ſeem too polluted, and disfigured, not to appear loathſome to him, *who is of purer eyes than to behold iniquity* without abhorrency; but when Chriſt interpoſes betwixt his eyes and us, we then ſeem far other things than otherwiſe we ſhould; and not only we do not appear filthy, but we do appear lovely, if not glorious. And as though ſome objects, as things purely white, and flames, look better through this glaſs, than homely and dirty ones; yet even theſe, looked upon through this glaſs, are more richly adorned, than the others beheld without it: ſo, whatever difference there may be betwixt perſons, that are either innocent, or exemplary, upon the bare account of morality; and thoſe ignorant or frail children of God, that, in themſelves conſidered, would be much inferiour to thoſe newly mention'd; yet when theſe are looked upon through Chriſt, they are much more acceptable in God's eyes, than the others conſidered out of him. And I ſhall add this further, that whereas my looking upon objects through the priſm, however it makes them appear to my eyes, does work no real change in the things themſelves, but leaves thoſe, that were homely and foul before, foul and homely ſtill; God's gracious looking upon us in Chriſt makes us by degrees become fit for his goodneſs to take delight in, and has an improving and transfiguring power on us; like the ſun, that cheriſhes green and unblown flowers, and paints them with their curiouſeſt colours, by his looking on them. Since then the Scripture tells us, that we are not only reconciled to God, but, if I may ſo expreſs it, are *ingratiated and endeared to him in the beloved*; how much do we owe to that bleſſed Saviour, upon whoſe account we enjoy the invaluable privilege to appear (and grow fit to do ſo) pleaſing in God's eyes? which, beſides that it is the higheſt honour, leads to the higheſt happineſs; or rather, is the one as well as the other.

An Advertiſement touching the Fourth Section.

A Reader, that is not unattentive, may eaſily collect from what he will meet with in ſome of the enſuing diſcourſes, that they were written ſeveral years ago, under an uſurping government, that then prevailed. And this may keep it from appearing ſtrange, that in papers, which contain ſome things not likely to be reliſhed by thoſe, that were then in power, the author ſhould take occaſion to ſpeak of himſelf as of another perſon; as well to avoid the being ſuſpected by them, in caſe his papers ſhould come into any of their hands, as to comply with the deſign he then had; that if theſe diſcourſes ſhould happen to be made publick, the reader might be left to gueſs, whether or no he were entertained with a fiction, or a true narrative. And though a change of circumſtances has occaſioned the publication of theſe papers, which ſhould have come forth by themſelves (if at all) in ſuch a way as will make moſt readers look upon them as containing a ſtory purely romantick; yet they may have in them much leſs of fiction, than ſuch will (it is like) imagine. For being really a great lover of angling, and frequently diverting my ſelf at that ſport, ſometimes alone, and ſometimes in company; the accidents of that recreation were the true themes, on which the following diſcourſes were not the only meditations I had made. Nor is the intimation given at the end of this (fourth) ſection, of a further continuation of ſuch diſcourſes, an artifice or ſhift, to ſteal away from a converſation I was unable to continue, without ſeeming to do ſo; there being in readineſs divers reflections relating to our anglers, which had furniſhed *Euſebius* and his friends with diſcourſes for the afternoon, if I had judged, that to invite an addition to ſo prolix an account as I had given of them already, nothing could be requiſite but a ſupply of thoughts.

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OCCASIONAL REFLECTIONS.

SECT. IV.

Which treats of Angling improved to ſpiritual uſes.

DISCOURSE I.

Upon the being called upon to riſe early on a very fair morning.

THE ſun had as yet but approached the eaſt, and my body as yet lay moveleſs in the bed, whilſt my roving thoughts were in various dreams, rambling to diſtant places; when, methought, I heard my name ſeveral times pronounced by a not unknown voice. This noiſe made me, as I was ſoon after told, half open my eyes, to ſee who it was that made it, but ſo faintly, that I had quickly let my ſelf fall aſleep again, if the ſame party had not the ſecond time called me louder than before, and added to his voice the pulling me by the arm. But though this waked me ſo far, as to make me take notice, that I was call'd upon to riſe, yet my drouſineſs, and my unwillingneſs to forgo a not unpleaſant dream, keeping me from diſcerning diſtinctly, who it was, that called me, made me briſkly enough bid him, whatever his buſineſs were, let me alone: but though at the ſame time I turned away my head to ſhun the light, though dim, which at the half-opened curtain ſhone in upon me, yet the party, inſtead of complying with my deſires, did by the throwing open the curtains, further let in ſo much more light upon my face, that finding it would not ſerve my turn to keep my eyes ſhut, I open'd them to ſee, who it was, that gave me this unwelcome diſturbance. This I had no ſooner done, than that I perceived that it was *Euſebius*, who with *Lindamor*, and two or three other friends, was come to call me to go a fiſhing, to a place, where by appointment we were to meet about ſun-riſing. The reſpect I paid *Euſebius*, and the value I placed upon his converſation, covered me with bluſhes to be thus ſurprized by him; and obliged me to ſatisfy him as well as I could, how much I was troubled and aſhamed to have the favour of his company brought me to my bed-ſide, when I ought, and intended to have waited on him. And thus, whilſt I was making him my apologies, and he was pleaſantly reproaching me for my lazineſs, and laughing at the diſorder I had not yet got quite out of, I made a ſhift haſtily to get on my clothes, and put my ſelf into a condition of attending him and the company to the river-ſide.

WHILST we were walking thither-ward, and *Lindamor* was minding *Euſebius* of the promiſe he had made the day before, to exerciſe, upon moſt of the things that ſhould occur to us, his art of making occaſional reflections, I was delighting my ſelf with the deliciouſneſs of that promiſing morning, and indeed the freſhneſs of the air, the verdure of the fields and trees, and the various enamel of the meadows, the muſick of the numerous birds, that with as melodious as chearful voices welcomed ſo fair a morning; the curious orient colours, wherewith the riſing ſun embelliſhed the eaſtern part of the ſky, and above all that ſource of light, who, though he ſhews us all, that we ſee of glorious and fair, ſhews us nothing ſo fair and glorious as himſelf, did ſo charm and tranſport me, that I could not hold expreſſing my ſatisfaction in terms, that, *Eugenius* was pleaſed to ſay, needed not rhymes to make them poetical. And the ſenſe of this invited me to add, that I now would not for any thing have miſſed being waked, and thought my ſelf hugely obliged to *Euſebius*'s freedom, that would not ſuffer me to ſleep out ſo glorious a morning, nor loſe the ſatisfaction of ſuch deſirable company.

Euſebius, who was but a little way off in diſcourſe with *Lindamor*, over-hearing a good part of what I had ſaid, thought fit to take thence a riſe, to begin complying with his friends requeſts; and accordingly, walking up towards me, and addreſſing himſelf to me, he told me, You are unconcerned enough, *Philaretus*, in what I am about to ſay, to make it allowable for me to tell *Lindamor*, that what has this morning happened to you, puts me in mind of what I have ſeveral times obſerved on another occaſion. For when a man is ſo lulled aſleep by ſenſual pleaſures, that, like one that ſleeps, he has but the faculty, not the exerciſe of reaſon, and takes his dreams for realities; if ſome ſerious divine, or other devout friend, concerned for the ſinner's ſoul, or his glory, that died to redeem it, endeavour to awaken him, and rouſe him out of that ſtate, wherein he lies ſo much at eaſe; ſuch attempts are wont at firſt to be looked upon by the lazy ſinner, enamoured of his eaſe, and preſent condition, but as pieces of unſeaſonable, if not uncivil officiouſneſs; and entertaining the light it ſelf but as an unwelcome gueſt, he obſtinately ſhuts his eyes againſt that, which alone makes them uſeful; and, inſtead of looking upon the attempter as his friend, he checks him, and expoſtulates with him, and uſes him almoſt as an enemy: inſomuch, that too often thoſe, that love the welfare of ſouls too little, or their own eaſe too much, forgo, with their hopes, their endeavours to reclaim him. But if, by God's bleſſing, upon the conſtancy of this kindneſs, and the letting in of ſo much light upon the ſinner, that he finds himſelf unable to continue his ſlumber any longer with it, he comes to be thoroughly awaked, he quickly grows ſenſible, that he is brought out of the kingdom of darkneſs, into a true and marvellous light; and, inſtead

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inſtead of thoſe empty fleeting dreams, which did before amuſe and delude him, and which, to reliſh, and be fond of, the eyes of his mind muſt be as well cloſed, as thoſe of his body, he is admitted to noble, and manly entertainments, ſuch as reaſon chuſes, conſcience applauds, and God himſelf approves. And this change of his condition he finds ſo advantageous, that he would not, for all the world, return again to that, he was at firſt ſo angry to be diſſuaded from; and he does not forgive, but thank the perſon, that diſquieted him, and bluſhes at the remembrance of his having reduced others to importune him to be happy: and, betwixt ſhame and gratitude, the ſenſe of his preſent, and of his paſt condition, poſſeſſing him, how much he has reaſon, to make his reſcuer as well amends for what he endured, as retributing for what he acted for him, he does, perchance, eſpecially in the firſt fervors of his zeal, think himſelf as much obliged to his awakener, as *Philemon* was to St. *Paul*, to whom, the Scripture ſays, that he owed even himſelf. And ſometimes ſuch a new convert, as I am ſpeaking of, will think his obligation, to the inſtrument of his change, ſo ſuitable to the tranſcendent ſatisfaction he finds in the change itſelf, that he would deſpair of ſeeing his benefactor ſufficiently recompenſed, if he did not remember a ſaying of the Prophet, (*That thoſe, that turn others to righteouſneſs, ſhall ſhine as the ſtars for ever and ever,*) that gives him ground to hope, that God himſelf (whoſe plenty, as well as bounty, is inexhauſted) will make the recompence his work. Wherefore, concludes *Euſebius*, if you chance to have any friends, (as it is odds moſt men have) that ſtand in need of this as great, as unwelcome, expreſſion of kindneſs, let us not be too ſoon diſcouraged, by finding the effects of our friendſhip coldly received, and poſſibly too looked upon as diſturbances; for beſides, that the leſs they are deſired, and the worſe they are entertained, the more they are needed; a Chriſtian is not bound, ſo much to concern himſelf in the ſucceſs of his endeavours, as to leave it in the power of every one that will be obſtinate, to make him unhappy, when the buſineſs, one way or other, come to an end, he may miſs his aim, without loſing his labour, ſince he ſerves a maſter, that is as ready to reward, as able to diſcern intentions; and, in caſe your endeavours do ſucceed, you will at once make a man your friend, and worthy to be ſo. And you ſhall ſcarce ever find men more affectionate to you, than thoſe you have made your friends by making them enemies to vice.

DISCOURSE II.

Upon the mounting, ſinging, and lighting of larks.

THE agreement we had made at our ſetting forth, that the motion of our tongues ſhould not hinder that of our feet towards the river-ſide, was the cauſe, that the paſt diſcourſes not having diſcontinued our walk, by that time they were ended, we began to traverſe certain plowed lands, that lay in the way betwixt us and the river. But we had ſcarce entered thoſe fields, when our ears were ſaluted with the melodious muſick of a good number of larks, whereof ſome mounted, by degrees, out of ſight, and others, hovering and ſinging a while over our heads, ſoon after lighted on the ground, not far from our feet.

AFTER we had a while enjoyed this coſtleſs, and yet excellent muſick, both *Euſebius* and I, chancing to caſt our eyes towards *Eugenius*, obſerved, that his did very attentively wait upon the motions of a lark, that, ſinging all the way upwards, and mounting, by degrees, out of ſight, not long after deſcended, and lighted among ſome clods of earth, which being of the colour of her body, made us quickly loſe ſight of her. Whereupon *Euſebius*, who was full as willing to hear as ſpeak, and, in the occaſional reflections that he made, was wont at leaſt as much to aim at the exciting others thoughts, as the venting of his own, begged *Eugenius* to tell us what it might be, which his attentiveneſs to the motions of the lark made us preſume he was thinking on.

Eugenius, after a little backwardneſs, which he thought modeſty exacted of him, ſoon anſwered us in theſe terms:

AMONG all birds, that we know, there is not any, that ſeems of ſo elevated, and, I had almoſt ſaid, heavenly a nature as the lark; ſcarce any give ſo early and ſo ſweet a welcome to the ſpringing day. And that, which I was juſt now gazing on, ſeemed ſo pleaſed with the unclouded light, that ſhe ſung as if ſhe came from the place ſhe ſeemed to go to; and during this charming ſong, mounted ſo high, as if ſhe meant not to ſtop, till ſhe had reached that ſun, whoſe beams ſo cheriſhed and tranſported her; and in this aſpiring flight ſhe raiſed herſelf ſo high, that though I will not ſay, ſhe left the earth beneath her very ſight, yet I may ſay, that ſhe ſoared quite out of ours. And yet when from this towering height ſhe ſtooped to repoſe or ſolace herſelf upon the ground, or elſe when to ſeize upon ſome worthleſs worm, or other wretched prey, ſhe lighted on the ground, ſhe ſeemed ſo like the earth, that was about her, that I believe you could ſcarce diſcern her from its clods. And whereas other birds, that fly not half ſo high, nor ſeem any thing near ſo fond of the ſun, do yet build their neſts upon trees, the lark does as well build hers upon the ground, as look like a part of it.

THUS I have known, in theſe laſt and worſt times, many a hypocrite, that when he was converſant about ſublimer objects, appeared, as well as he called himſelf, a ſaint; nothing ſeemed ſo unwelcome to him as new light; one might think his lips had been touched with a coal from the altar, his mouth did ſo ſweetly ſhew forth God's praiſe, and ſacred diſpenſations. In ſum, take this hypocrite in his fit of devotion, and to hear him talk, you would think, that if he had not been already in heaven, at leaſt he would never leave mounting, till he ſhould get thither.

BUT when the opportunities of advantaging his lower intereſts called him down to deal about

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about ſecular affairs here below, none appeared more of a piece with the earth than he, for he looked, as if he had been beſmeared all over with the earth round about him, and he ſeemed, in providing for his family, to be of a meaner and a lower ſpirit, than thoſe very men, whom in diſcourſe he was wont to undervalue, as being far more earthy than himſelf.

SINCE we know, ſays *Euſebius*, that the beſt things corrupted prove the worſt, it can be no diſparagement to piety, to acknowledge, that hypocriſy is a vice, which you cannot too much condemn. And when the pretending of religion grows to be a thing in requeſt, many betake themſelves to a form of religion, who deny the power of it; and ſome perchance have been preferred leſs for their *Jacob*'s voice than for their *Eſau*'s hands.

BUT, *Eugenius*, let us not, to ſhun one extreme, fondly run into the other, and be afraid or aſhamed to profeſs religion, becauſe ſome hypocrites did but profeſs it: his courſe is ignoble, and prepoſterous, that treads the paths of piety, rather becauſe they lead to preferment than to heaven; but yet it is more excuſable to live free from ſcandal for an inferiour end, than not to live ſo at all: and hypocrites can as little juſtify the profane, as themſelves. It may be, that all, that own religion, are not pious; but it is certain, that he, that ſcorns to own it, muſt leſs be ſo. And if ſcoffers at piety ſhould ſucceed the pretenders to it, they cannot be ſaid (as ſometimes they would be thought) to be an innocent ſort of hypocrites, that are better than they ſeem; for ſcandal is a thing ſo criminal, and contagious, that whoſoever deſires, and endeavours to appear evil, is ſo: to refuſe to be religious, becauſe ſome have but profeſſed themſelves to be ſo, is to injure God, becauſe he has been injured. A ſkilfull jeweller will not forbear giving great rates for necklaces of true pearl, though there be many counterfeits for one that is not ſo; nor are the right pearls a whit the leſs cordial to thoſe, that take them, becauſe the artificial pearl made at *Venice*, conſiſting of mercury and glaſs, for all their fair ſhew, are rather noxious, than medicinal. And indeed our knowledge, that there are hypocrites, ought rather to commend piety to us, than diſcredit it with us; ſince as none would take the pains to counterfeit pearls, if true ones were not of value; ſo men would not put themſelves to the conſtraint of perſonating piety, if that it ſelf were not a noble quality. Let us then, *Eugenius*, fly as far as you pleaſe from what we deteſt in hypocrites: but then let us conſider, what it is that we deteſt; which being a bare, and therefore falſe pretence to religion, let us only ſhun ſuch a pretence, which will be beſt done by becoming real poſſeſſors of the thing pretended to.

DISCOURSE III.

Upon the ſight of a fair milk-maid ſinging to her cow.

EUGENIUS, who was not at all indiſpoſed to liſten to exhortations of this nature, not only embraced this made him by his friend, but with earneſtneſs enough continued the conference to explain his meaning, and ſatisfy *Euſebius*, that he did not think piety fit to be diſcountenanced, though he thought hypocriſy was ſo; and that he was no enemy to the profeſſion of religion, but to thoſe, that blemiſhed it by unſuitable practices. And with ſuch kind of diſcourſes we continued our walk, till being come to a ſtyle, over which we were to paſs out of one meadow into another, I chanced to ſtop, and turn about to pay *Lindamor* the reſpect of deſiring him to lead me the way over: but not finding him there, I haſtily caſt my eyes all over the field, till at length they diſcovered him a good way off, in a poſture, that ſeemed extremely ſerious, and wherein he ſtood as immoveable as a ſtatue. This ſight ſoon carried me towards him, and I had diſpatched half my way, before his changing his poſture gave him an opportunity to diſcover me; which as ſoon as he did, he immediately came to meet me, and almoſt before I had aſked him the occaſion of what I had ſeen, Whilſt (replied he) *Eugenius* was purging himſelf from a fault, that none that knows him will ſuſpect him to be guilty of; I was detained a little behind you by the muſick of one of thoſe larks, whoſe melody was ſo charming, that I could not find in my heart to make haſte from it: but whilſt I was liſtening to it, my attention was diverted by a nobler object; for I heard from the further corner of this meadow, a voice, which, though not governed with ſkill, did ſo repair the want of it by its native ſweetneſs, that art was abſent without being miſſed, and I could not but have ſome curioſity to ſee, who was the poſſeſſor of ſo much power to pleaſe. Turning then my ſteps towards that part of the field, whence the voice came, my eyes quickly ceaſed to envy my ears; for they diſcovered, kneeling by a cow, and ſinging to her whilſt ſhe milked her, a perſon, who, in the habit of a milk-maid, ſeemed to diſguiſe one of thoſe nymphs, that poets are wont to deſcribe to us. And that you may not wonder, continues *Lindamor*, at what I ſhall ſay to you of a country girl, know, that methought I ſaw in her face ſomething more like *Hermione*, before ſhe proved inconſtant, than I expected to find in any of her ſex. I will not tell you, that this fair creature had the bluſhes of the morning in her cheeks, the ſplendor of the ſun in her eyes, the freſhneſs of the fields in her looks, the whiteneſs of the milk ſhe expreſſed in her ſkin, and the melody of the larks we were admiring in her voice, leſt you ſhould think Mr. *Boyle*'s Seraphick Love had loſt its operation on me. But I may perhaps, without much hyperbole, give you this account of her, that though her clothes are almoſt as coarſe as cleanly; and though they are ſuited to her condition, yet they are very ill ſuited to her beauty; which, as if nature intended a triumph over fortune, has, without any aſſiſtance of ornament, more diſtreſſed my liberty, than others have been able to do with all their moſt curious dreſſes. And this fair creature, continues *Lindamor*, as ſhe is rich in nature's bounty, appeared as well by the chearfulneſs

of the tune ſhe ſung, as by the manner of her ſinging it, ſo ſatisfied with the unpurchaſed treaſures ſhe poſſeſſes, that ſhe ſeemed almoſt as much pleaſed as I was to look upon her. This character of *Lindamor*'s inviting me to go ſee, whether or no it were deſerved; and the frequent experience I have had, that even upon ſuch bright eyes as poets, and lovers, called ſuns, I could gaze undazzled enough to approve my ſelf a right eagle, aſſuring me I might ſafely do it, I fearleſly, but ſoftly, approached the place, where the fair milk-maid was ſolliciting the udder of a freſh cow; and I found, that though indeed ſome reſemblance ſhe had to *Hermione* had made *Lindamor* flatter her, yet ſhe looked at once ſo innocently, and prettily, that ſhe ſeemed like to do miſchief, without at all intending it; and I could not but fancy, that if ſome ladies, that are much cried up, and are very imperious miſtreſſes, becauſe they are ſo, were bound to change dreſſes with this unſophiſticated and unadorned maid, the one would appear to owe her beauty to art, and the other to be beholden for her's to nothing but nature. But *Lindamor*, who is not naturally indiſpoſed to be amorous, did not think, that this imagination of mine did that pretty creature right; for when I told him, ſhe would eclipſe a hundred of our fine ladies, if ſhe had but the dreſs of one of them, why, that (replies he, with a kind of indignation) ſhe can do without it; and perhaps, (ſubjoins he,) as much as with it. For her preſent habit leaves her moſt her ſelf; and bravery would but diſguiſe, or hide what it cannot adorn. And I am confident, (continues he) that ſhould ſuch a genuine beauty appear among the gallants, ſhe would really captivate many, even of thoſe wary ones, that do but pretend to be ſo, to the deſigning and applauded ladies; for though ſkill may encounter the wiles of art, it would ſcarce be able to reſiſt the charms of nature. But whilſt *Lindamor* was thus complementing with what he fancied the picture of his once loved *Hermione*, and had his eyes as much fixed upon her, as dazzled ones could be, the lovely milk-maid, (who all this while having not taken notice of us, was as regardleſs of *Lindamor*, as he ſeemed to be of all things but her) having diſpatched what ſhe was doing, took up her pail to carry it homewards: but her way chancing to lie by that part of the meadow, where we were yet ſtanding, ſhe could not but diſcover us; and judging by our clothes, and more by *Lindamor*'s mien, that we were of a quality differing from theirs ſhe was wont to converſe with, ſhe gave us a ſalute low enough to let us ſee, that ſhe forgot not her condition; but attended with ſo much gracefulneſs, as made *Lindamor* conclude ſhe merited a better, and, as ſhe paſſed by him, to return the geſture of reſpect, which he thought ſo much beauty had a right in any habit to exact. She vouchſafed him a ſmile, which, I after told him, would have made him happy, if he had thought it had proceeded from kindneſs, not civility; and ſhe went away with a look ſo ſerene, as well as taking, that ſhe ſeemed to carry home with her far more quiet, than ſhe left him poſſeſſed of. But I, that had loſt ſight of her, without loſing any thing with it, ſave the expectation of ſeeing in haſte ſo fair a milk-maid, was going to railly with *Lindamor* about what had paſſed, when I was reſtrained, by perceiving, that the ſight of a perſon, that ſeemed ſo contented, together with the native pleaſantneſs of that place, and of that glorious morning, had ſuch an operation upon him, that he could not forbear to celebrate the happineſs and innocency of a country life. And after he had, with much tranſport, and fluency, repeated the ſubſtance of what *Ovid* and other ancient poets had in their ſtrain delivered, concerning the felicity of the golden age, he began to apply as much of it as the matter would bear, to the recommending of a rural life; and was very ſollicitous to make me acknowledge, that though we are wont to look upon villagers, as an inferiour and wretched ſort of people, yet they are the perſons of the world, whoſe condition is the moſt proper, not only to keep them innocent, but to make them happy; their cheap and ſimple way of living allowing them to reſt contented with what bounteous nature has provided for them, or an eaſy induſtry can procure them. Whereas among men nobly born, or perſons of quality, it is looked upon as want of breeding, for a man not to think himſelf unhappy, as long as he hath not a thouſand pounds a year.

LINDAMOR, though he here made a pauſe to take breath, would yet perhaps have proſecuted his diſcourſe, had he not been prevented by the invervening of *Euſebius*, who, a while after we had left him, having miſſed us, had followed us to the place he found us in, and who, when he drew nigh, having overheard *Lindamor* ſpeaking, ſtood ſtill a while at ſome diſtance off, to liſten to what he ſaid, and ſo became an unſuſpected auditor of the laſt part of his friend's diſcourſe. Whereupon taking him by the hand, and leading him towards the river, he told him, with a ſerious, not to call it a ſevere look; I had thought, *Lindamor*, you had made righter eſtimates of the ſeveral courſes of life, than by what I have newly over-heard you to ſay, I now ſuſpect you do. Know then, *Lindamor*, (adds he) that innocence and contentment depend more upon a man's mind, than upon his condition. To manifeſt this to you, I ſhall in the firſt place obſerve, that it is not always the occaſion, or the object, but rather the degree, that makes an affection of the mind unruly and troubleſome: nor is it according to the intrinſick value of things, which none ſave the wiſe can diſcern; but the rate, how unſkilfully ſoever fixt, which we put upon them, that they operate upon our paſſions. And therefore, you ſhall ſee a child take on more ſadly for the ſcape of a ſparrow, or the breaking of a rattle, than ſome will do for the loſs of a good eſtate, nay, of a friend; and *Haman*, for the want of a bow from *Mordecai*, com-

plained more in his palace, than *Job*, till his miſerable comforters had exaſperated his grief, did for the loſs of the biggeſt fortune in the Eaſt, and of the children he reſerved it for, and valued far above it.

AND then, *Lindamor*, (continues *Euſebius*) do not imagine, that though courtiers and gallants have more ſplendid and glittering temptations to ſin and diſcontent, country people are exempted from temptation to either: theirs may be as great, though not the ſame, nor ſo ſpecious as the other; their faults and infelicities are indeed leſs taken notice of, becauſe their perſons and conditions are obſcure, and their poverty conceals their vices, as well as their virtues, from our eyes; as in a ſharp winter, the ſnow does as well hide their dung-hills, as cover their gardens. But if your quality allowed you to acquaint yourſelf with the true ſtate of this inferiour ſort of people, you would ſoon perceive, that even of rural families, there is ſcarce any, that, as far as their wits will reach, has not its ſeveral parties, and little intrigues; nor is there any cottage ſo low, and narrow, as not to harbour care, and malice, and covetouſneſs, and envy, if thoſe, that dwell in it, have a mind to entertain them. And what envy alone may do to produce crimes and diſcontents, we may conjecture by what happened betwixt *Cain* and *Abel*, ſince their being heirs to the whole world could not keep two brothers at peace, whilſt one of them was envious: and there are ſome ſordid vices, which are more incident to the meaner and more neceſſitous ſort of men, as ſpiders and cobwebs are wont to abound more in thatched cabins, than in great men's houſes. I ſhould perhaps (ſays *Euſebius*) think theſe people happy, if I found they thought themſelves ſo; but the pomp and vanities of the world have oftentimes ſtronger allurements for them, than for the grandees and courtiers themſelves: for thoſe, that are poſſeſſed of theſe imaginary joys, are diſabuſed by their own experience; and thoſe, that live among theſe theatrical perſons, are near enough to diſcern, that they are but cauſeleſly envied. As, for my part, when I had occaſion to be converſant in great men's families, and the honour to preach in princes courts, the ſight of their courſe of life did as thoroughly convince me of the vanity of the world, as my ſermons endeavoured to convince them. Whereas country people ſee but the glittering and deluding outſide of greatneſs; and beholding it but at a diſtance, ſee it in the favourableſt light which men can behold it in; and conſequently are ſtrongly tempted to envy what they admire, and repine at their own condition, for the want of it: nay, every gaudy trifle, that thoſe that live in towns and cities chance to make ſhew of, is wont to make a country-man envy, as well as gape; and it is odds, but that very milk-maid, whoſe condition you are pleaſed to think ſo happy, envies ſome neighbouring farmer's daughter for a piece of taudry ribbon, or a black hood. Nor are they ſo much more privileged from the aſſaults of temptation, than men of higher rank; for it is not ſo much a man's outward condition, as his inward diſpoſition and temper of mind, that makes temptations either to ſin, or to diſcontent, prevalent, or unſucceſsful. When *Joſeph* was ſold into *Egypt*, and ſollicited by a woman, that would needs be his miſtreſs upon more ſcores than one, though his condition expoſed him more to hopes and fears, than almoſt any other condition could expoſe another man; and though his youth made him very capable of reliſhing the pleaſures, that his beauty made him courted to receive, by giving them; yet this chaſte youth choſe rather to be impriſoned any where, than in a fair lady's arms, and preferred the being made a captive, before the captivating of his amorous miſtreſs. But whilſt young *Joſeph* was thus chaſte in the Egyptian *Potiphar*'s houſe, his eldeſt brother *Reuben* was inceſtuous in good *Jacob*'s, whoſe family was then the viſible church of God; and *Lot*, who was chaſte and temperate in *Sodom* itſelf, was drunk, and committed inceſt in a cave: ſo much more does the ſucceſs of temptations depend upon the temper of a man's mind, than upon the place he lives in.

I KNOW not (ſays *Eugenius*) whether the innocence of rural people be more eaſy than that of great men, but ſure it is not ſo commendable: for as a woman, that has never yielded, becauſe ſhe was never ſollicited, may be called rather innocent than virtuous; ſo their condition, that owe their not being inveigled by the vanities of the world to their ignorance of them, has more in it of good fortune than of merit. I thank you for that conſideration, (ſubjoins *Euſebius*) for I confeſs I think there is a great diſparity betwixt an unacquaintedneſs with the bewitching pleaſures of the world, and a contempt of them. And he is the truly heroick ſpirit, that can (as *David* could) plentifully enjoy all thoſe ſenſual delights and vanities he choſe to reject: for he could feaſt a nation, and prefer temperance before all that abundance: he could gain ſtrange victories at once over his outward enemies, and over the temptations he was expoſed to by ſuch ſucceſſes: he could build ſtately palaces, and then profeſs himſelf to be but *a ſtranger, and a ſojourner upon earth*: he could afford humility room to ſit with him on his throne, and could liſten to her memento's amidſt all the acclamations of his people, and the panegyricks of his courtiers: he was not to be reſiſted by beauties, that to others were irreſiſtible, when he poſtponed the faireſt objects, that could here charm his eyes, to ſuch as were viſible only to thoſe of faith: he had got together the greateſt treaſure, that for aught I remember we read of in any hiſtory, and yet ſeems never to have been much pleaſed with it, but when he dedicated it to the building of the temple, and made the fruits of his valour the oblation of his piety. To be ſhort, he was the greateſt perſon upon earth, when he was content to leave it; and was willing to deſcend from the throne into the grave, whilſt he looked upon that as the place whence he muſt aſcend to the manſion of his God: ſo much did he, even whilſt he wore an earthly crown, aſpire to an heavenly one. And though

(continues

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(continues *Euſebius*) we muſt now-a-days as little expect to meet with a man of *David*'s condition, as of his temper, yet proportionably we may put a vaſt difference betwixt thoſe that but eſcape the ſight of the world's allurements, and thoſe that reject the profers of them.

Euſebius was in this part of his diſcourſe, when we were come near enough to the river, to diſcover it within a little way of us: and therefore finding by his ſilence, that he thought it ſeaſonable to deſiſt, I only ventured to tell him with a low voice, as we continued our walk, that I ſuſpected, that in ſome of the things he had been ſaying, he had a deſign rather to check *Lindamor* a little, and keep up the diſcourſe, than to deny, that a retired and rural life has great advantages towards contentation. To which, that he might conclude what he had to ſay, before we reached the river, he made haſte to reply in the ſame tone, that I was not altogether miſtaken; for (ſays he) I think the caſe may be pretty well repreſented, by ſaying, that as there are ſome airs very much wholeſomer than others, and fitter to preſerve men from diſeaſes; ſo a very private and quiet condition of life does, much more eaſily than a more expoſed and turbulent one, protect moſt ſorts of men from vices and diſquiets. But then, on the other ſide, as there are ſome men of ſuch ſound and ſtrong conſtitutions, that they will enjoy their health in the worſt airs, when men of tender and vitiated complexions will be ſickly in the beſt; ſo there are ſome generous and ſteady ſouls, that will paſs thorough the moſt troubleſome and moſt expoſed courſes of life, with more of both innocence and contentment, than others can enjoy in a condition far remoter from diſturbances and temptations. And, annexes *Euſebius*, (purpoſely raiſing his voice) as for theſe villagers, that *Lindamor* thought ſo happy, I muſt diſſent from him, as long as I ſee they can admire, and almoſt worſhip, a man for wearing a gaudy ſuit of clothes, or having two or three footmen behind his coach, before they know whether he be not a knave, or a fool, or both: for I ſhall ſcarce think, that he, who is himſelf poſſeſſed with envy, deſerves mine.

DISCOURSE IV.

Upon fiſhing with a counterfeit fly.

BEING at length come to the river-ſide, we quickly began to fall to the ſport, for which we came thither; and *Eugenius* finding the fiſh forward enough to bite, thought fit to ſpare his flies, till he might have more need of them, and therefore tied to his line a hook, furniſhed with one of thoſe counterfeit flies, which in ſome neighbouring countries are much uſed, and which being made of the feathers of wild-fowl, are not ſubject to be drenched by the water, whereon thoſe birds are wont to ſwim. This fly being for a pretty while ſcarce any oftener thrown in, than the hook it hid was drawn up again with a fiſh faſtened to it, *Eugenius* looking on us with a ſmiling countenance, ſeemed to be very proud of his ſucceſs; which *Euſebius* taking notice of, Whilſt, (ſays he) we ſmile to ſee, how eaſily you beguile theſe ſilly fiſhes, that you catch ſo faſt with this falſe bait, poſſibly we are not much leſs unwary ourſelves; and the world's treacherous pleaſures do little leſs delude both me and you: for, *Eugenius*, (continues he) as the Apoſtles were fiſhers of men in a good ſenſe, ſo their and our grand adverſary is a ſkilful fiſher of men in a bad ſenſe; and too often in his attempts, to cheat fond mortals, meets with a ſucceſs as great and eaſy, as you now find your's. And certainly, that tempter, as the Scripture calls him, does ſadly delude us, even when we riſe at his beſt baits, and, as it were, his true flies: for, alas! the beſt things he can give, are very worthleſs, moſt of them in their own nature, and all of them in compariſon of what they muſt coſt us to enjoy them. But, however, riches, power, and the delights of the ſenſes are real goods in their kind, though they be not of the beſt kind; yet, alas, many of us are ſo fitted for deceits, that we do not put this ſubtile angler, to make uſe of his true baits to catch us! We ſuffer him to abuſe us much more groſsly, and to cheat us with empty titles of honour, or the enſnaring ſmiles of great ones, or diſquieting drudgeries diſguiſed with the ſpecious names of great employments. And though theſe, when they muſt be obtained by ſin, or are propoſed as the recompences for it, be, as I was going to ſay, but the devil's counterfeit flies; yet, as if we were fond of being deceived, we greedily ſwallow the hook, for flies, that do but look like ſuch; ſo dim-ſighted are we, as well to what vice ſhews, as to what it hides. Let us not then (concludes *Euſebius*) riſe at baits, whereby we may be ſure to be either groſsly, or at leaſt exceedingly deceived; for whoever ventures to commit a ſin, to taſte the luſcious ſweets, that the fruition of it ſeems to promiſe, certainly is ſo far deceived, as to ſwallow a true hook for a bait, which either proves but a counterfeit fly, or hides that under its alluring ſhew, which makes it not need to be a counterfeit one to deceive him.

DISCOURSE V.

Upon a fiſh's ſtruggling after having ſwallowed the hook.

FORTUNE ſoon offered *Euſebius* a fair opportunity to confirm this laſt part of his reflection; for he had ſcarce made an end of it, when a large fiſh, eſpying the fly, that kept my hook ſwimming, roſe ſwiftly at it, and having greedily chopt it up, was haſtily ſwimming away with it, when I ſtruck him, and thereby ſtopt for a while his progreſs: but finding himſelf both arreſted and wounded, he ſtruggled with ſo much violence, that at length he broke my ſlender line, (that was fitted but for weaker fiſhes) and carried away a part of it, together with the annexed hook and bait. If philoſophers (ſays hereupon *Euſebius*) be not too liberal in allowing brutes to think, we may well ſuppoſe, that this fiſh expected a great deal of pleaſure from the bait he fell upon ſo greedily; and that when once he had got it into his mouth, he might well look upon it

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it as his own; and thoſe other fiſhes, that ſaw him ſwallow it, and ſwim away with it, did probably envy his good fortune. But yet indeed he does not enjoy his wiſh, though he ſeem to have the thing wiſhed for within his power; for by the ſame action, in which he ſucked in the fly, he likewiſe took in the hook, which does ſo wound and tear his tender gills, and thereby put him into ſuch reſtleſs pain, that no doubt he wiſhes, that the hook, bait, and all, were out of his torn jaws again, the one putting him to too much torture to let him at all reliſh the other. Thus men, who do what they ſhould not, to obtain any object of their ſenſual deſires, whatever pleaſure they may beforehand fancy to themſelves in their ſucceſs, are oftentimes, even when they obtain their ends, diſappointed of their expectations; ſometimes conſcience, reaſon, or honour, making them, even when their deſires are not of the worſt ſort, do as *David* did, when he had, more vehemently than became a pious general, longed for water out of the well at *Bethlehem*; and by the ſtrange venturouſneſs of his bold and affectionate officers obtained it, could not find in his heart to drink it, but poured it untaſted on the ground. But when the things we ſo long for muſt be criminally obtained, then it not only often fares with them, as it did with *Amnon*, who immediately upon the inceſtuous fruition of his raviſhed ſiſter, hated her more than before he had loved her: but it ſometimes happens to thoſe, that ſin more heinouſly in this matter, as it did to *Judas*, who, after having betrayed a maſter, that was incomparably more worth than all the world, and thereby for ever loſt himſelf for a few pieces of ſilver, ſeemed to have it in his power, without having it in his will, to enjoy them, and in a deſperate but unſeaſonable fit of anguiſh and remorſe, did of his own accord diſburthen himſelf of that money, which he had ſold his conſcience to get; ſo that though he had what he ſought, he had not what he expected. And when what he coveted was in his poſſeſſion, he had the guilt of acquiring it, without the power of enjoying it. And even in caſes far leſs heinous, (concludes *Euſebius*) when men ſeem to have got what they aimed at, and to have carried it away as their booty, in ſpite of all oppoſition the wound thereby inflicted on injured conſcience puts them to ſo much of deſerved pain, that the wiſhes they are thus criminally poſſeſt of, they do not enjoy, but deteſt.

DISCOURSE VI.

Upon the ſight of one's ſhadow caſt upon the face of a river.

THE ſight of ſome fiſhes playing to and fro upon the top of the water diverted us from proſecuting our conference, and drew us to apply our ſelves attentively to the catching of them, in which accordingly we ſpent ſome part of the morning; yet whilſt we continued angling, not far from one another, we often caſt our eyes (as is uſual in ſuch caſes) upon each other's fiſhing corks, to learn as well the ſucceſs of our friends, as in what places the fiſh were forwardeſt to bite. As I chanced to look towards that cork, at which *Euſebius*'s hook was hanging, I perceived, that it was divers times drawn under water, without his endeavouring thereupon to ſtrike that fiſh, that made thus bold with his bait: wherefore laying down my angle a while, I went ſoftly towards *Euſebius*, to ſee what it was, that made him ſo regardleſs of his ſport, whilſt yet, by the poſture he continued in, he ſeemed to be intent upon it; but approaching near enough, I quickly perceived, that inſtead of minding his hook, his eyes were fixt ſometimes upon his own picture, reflected from the ſmooth ſurface of the gliding ſtream, and ſometimes upon the ſhadow projected by his body, a little beſide the picture upon the ſame river.

THE unwilling noiſe I made in coming ſo near having obliged *Euſebius* to take notice of me, I thought fit, ſince I found I was diſcovered, to aſk him ſmilingly, whether he were, *Narciſſus*-like, making love to his own ſhadow.

EUSEBIUS gueſſing by theſe words, that I had conjectured what he was doing, anſwered me with a look ſomewhat more ſerious than that I had ſpoken to him with; I was indeed, *Philaretus*, attentively enough conſidering, ſometimes my picture, which the water preſents me with, and ſometimes the ſhadow, which the ſun and I together caſt upon the water: but (ſays he, with a half ſmile) I looked upon both theſe, not with the eyes of a *Narciſſus*, (for that would make me much madder than he was) but with thoſe of a Chriſtian. For I was conſidering, that one of the differences betwixt the law, and the goſpel, might not be ill repreſented by the difference betwixt a common looking-glaſs, and that afforded me by this cryſtal ſtream: for though, both being ſpecular bodies, I can ſee my face in either; yet if my face be ſpotted with dirt, or grown pale by reaſon of the faintneſs uſual in ſuch hot weather, a common looking-glaſs will indeed diſcover thoſe things to me, but will not otherwiſe aſſiſt me to remedy them: whereas, when I conſult this ſtream, if it ſhew me any ſpots in my face, it ſupplies me with water to waſh them off, and by its cooling and refreſhing waters, can relieve me from that faintneſs, that reduces me to look pale.

THUS the law, which is commonly, and which ſeems even by an Apoſtle to be compared to a looking-glaſs, ſhews us indeed the pollutions of our ſouls, and diſcovers to us the effects of our ſpiritual languidneſs, and faintneſs; but the goſpel does not only do ſo, but tells the embracers of it, by Saint *John's* mouth, *If any man ſin, we have an advocate with the Father, Jeſus Chriſt the righteous, who is the propitiation for our ſins, and whoſe blood cleanſes us from all ſin.* And the author of the ſame goſpel invites all thoſe, that find themſelves tired and thirſty, to come unto him, and to be refreſhed.

BY this time *Lindamor*, who was angling not very far off, perceiving us ſtand together,

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as if we were engaged in ſome diſcourſe, laid by his rod a while, and came to liſten to what he expected he might learn from *Euſebius*; who pauſing here, I put him in mind, that he had alſo mentioned to me the ſight of his ſhadow upon the face of the river, as another object of his contemplations, and that therefore my curioſity (wherein I knew *Lindamor*, as ſoon as I ſhould acquaint him with the occaſion, would ſhare) made me very deſirous to know what thoughts had been ſuggeſted to him by a ſubject, that ſeemed ſo ſlight and barren.

SINCE you will needs know, (replies *Euſebius*) I will confeſs to you, that my thoughts were theologically enough employed, and therefore, leſt you ſhould think, I affect to preach out of the pulpit, I will but ſuccinctly mention ſome of thoſe various things, that this ſhadow, as deſpicable as you think it, ſuggeſted to me: but ſince I was only entertaining and exciting my ſelf, not diſcourſing with Naturaliſts, or diſputing with Atheiſts, I preſume you will not wonder, that I take the doctrine of the creation for granted, as it is acknowledged by Chriſtians in general, and particularly by you.

I WAS then conſidering, that this ſhadow, related to me, might in ſome particulars be no unfit one of the univerſe in reference to God: and indeed, perhaps the world may without much extravagance be termed the ſhadow of him, of whoſe attributes, or perfections, it exhibits to an attentive conſiderer divers excellent impreſſes, and the reſemblance may thus far be advanced: that as though it repreſents the ſhape and out-lines of my body, which projects it, yet it repreſents but them, and conſequently this ſhadow in reference to it is but a ſuperficial and worthleſs thing; ſo the world, though it be not deſtitute of ſeveral impreſſes, and as it were lineaments or features of the divine wiſdom and power, yet, for all this, its repreſentations of the divine author of it are but very imperfect, ſuperficial, and dark, and the excellency of the adorable author of things keeps him infinitely above all the works, that he has made.

BUT to mention ſome of the compariſons I took notice of: In the firſt place we may conſider, that I make this ſhadow here without taking the leaſt pains to do ſo, and with as little toil God made the world: *He ſpake and it was done; he commanded, and it ſtood faſt*, (ſays the Pſalmiſt, ſpeaking of the creation.) And elſewhere the ſcripture ſays, *That the everlaſting God, the Lord, the Creator of the ends of the earth fainteth not, neither is weary*; and therefore that reſt aſcribed him on the ſeventh day is to be underſtood but a ceſſation from creating, not a repoſe from labour: for all diſproportions to the power of created agents are ſo equally inconſiderable, in reference to one that is infinite, that omnipotence may make even the world without toil.

Pſ. xxxiii. 9.

Iſaiah xl. 28.

SECONDLY, To make this ſhadow, I neither uſe nor need colours, nor pencil; I dig no quarries, nor fell no trees to perfect this work, and employ no materials about it: as little had God any pre-exiſtent matter to contrive into this vaſt fabrick: our creed proclaims him the Creator of heaven and earth; the angel, that holds the book, in the *Revelations*, deſcribes him reſemblingly; and the Apoſtle tells us, *That through faith we underſtand, that the worlds were framed by the word of God; ſo that things, which are ſeen, were not made of things, that do appear*. And indeed it became an omnipotent architect, not to be beholden but to himſelf for his materials. He that calleth things, that are not, as though they were, makes them by calling them; *He brought forth light out of darkneſs, by calling for light, and there was light; and he ſpake it, and it was done*, ſays the Pſalmiſt: and the world was, if I may ſo expreſs it, but the real echo of that productive *FIAT*.

Revel. x. 6.

Hebr. xi. 8.

THE next thing, I was conſidering, was, that, to deſtroy this ſhadow, I needed neither ſword, nor piſtol, the withdrawing of my ſelf under the neighbouring trees being ſufficient to make the ſhadow diſappear, and leave behind as little ſhape of it, as if there never had been any. And thus, as the world could not have had a beginning, without having been provided by God, ſo for the continuance of the being it enjoys, it depends altogether, and every moment, upon the will and pleaſure of its firſt author, of whom St. *Paul* tells us, *That in him we not only live, and move, but have our being*; and to the ſame purpoſe I think one may alledge that place, where the ſcripture ſays of God, not only, *that he has made heaven, the heaven of heavens with all their hoſt, the earth and all things that are thereon, the ſeas and all that is therein*; but adds, *that he preſerveth them all*, as our tranſlators Engliſh it: for in the Hebrew I remember it is, *vivifies them all*, that is, ſuſtains them in that improper kind of life, or that exiſtence, which, whilſt their nature laſts, belongs unto it. So that if God ſhould at any time withdraw his preſerving influence, the world would preſently relapſe, or vaniſh into its firſt nothing, as there are many notions of the mind ſuch, as that of genus, and ſpecies, which are ſo the creatures of reaſon, that they have no longer an exiſtence in the nature of things, than they are actually upheld therein, by being actually thought upon by ſome intellectual being; and God is ſo the preſerver of all his creatures, that one may ſay of the reſt, as the Pſalmiſt ſpeaks of many of them, where addreſſing himſelf to God, he ſays, *Thou hideſt thy face, they are troubled; thou takeſt away their breath, they die, and return to their duſt; thou ſendeſt forth thy ſpirit, they are created*, &c.

Nehemiah ix. 6.

Pſal. civ. 29, 30.

I WAS alſo taking notice, (purſues *Euſebius*) that to produce what changes I pleaſed, in all, or any part of this ſhadow, I needed not employ either emiſſaries, or inſtruments, nor ſo much as rouſe up my ſelf to any difficult exertion of my own ſtrength, ſince, by only moving this or that part of my own body, I could change at pleaſure, in the twinkling of an eye, the figure and poſture of what part of the ſhadow I thought fit: and thus, when God had a mind to work thoſe miracles, we moſt admire, as when at *Joſhua*'s prayer he ſtopped

the courſe of the ſun, and at *Hezekiah*'s, made him go back; we men are apt to imagine, that theſe prodigious effects muſt needs coſt their author much, and that he muſt ſtrain his power, and be neceſſitated to a troubleſome exertion of his omnipotence, to be able to produce them: whereas to that divine agent, thoſe things, that would be to all others impoſſible, are ſo far from being difficult, and the creatures have ſo abſolute and continual a dependance on him, that it is as eaſy for him to effect the greateſt alterations in them, as to reſolve to do ſo. And even thoſe miraculous changes of the courſe of nature, that do the moſt aſtoniſh us, do ſo naturally and neceſſarily flow from the motions of his own will, that to decree, and to execute, (whether or no they require powers otherwiſe than notionally differing) are alike eaſy to him: and that irreſiſtable agent finds as little more difficulty to produce the greateſt changes among the creatures, than to produce the leaſt, as I find it harder to move the whole arm of my ſhadow, than to move its little finger. And this conſideration (ſubjoins *Euſebius*) might be, methought, conſolatory enough to his church, who, by repoſing an entire truſt in her God, entitles her ſelf to the protection of him, that can as eaſily produce changes in the world, as reſolve on them, and can with the ſame facility deſtroy her and his greateſt enemies, as decree their deſtruction.

I WAS alſo further conſidering, (ſays *Euſebius*) that though the little watry bodies, that make up this river, and conſequently thoſe, that glided along by me, were in a reſtleſs motion, the hindmoſt always urging on, and chaſing thoſe that were before them; yet my ſhadow was as compleat and ſtable upon the fugitive ſtream, as if it had been projected on the water of a pond, or rather as if all the parts of water, whereon it was viſible, had been fixt and moveleſs; of which I made this application, that though we may ſay with *Solomon*, in a larger ſenſe than his, *That one generation goes, and another comes*, the world being maintained by perpetual viciſſitudes of generation and corruption, yet the wiſdom and providence of God does ſo far confine the creatures to the eſtabliſhed laws of nature, that though vaſt multitudes of individuals are always giving place to others, yet the particular creatures, which do at any time make up the world, do always exhibit the like picture of its divine original.

BUT yet laſtly, (ſays *Euſebius*) I was conſidering too, that though this ſhadow have ſome kind of reſemblance to that, whoſe ſhadow it is, yet the picture is but very ſuperficial and obſcure; and if we ſhould ſuppoſe, the fiſhes, that inhabit this ſtream, to be endued with reaſon, they could even from *Lindamor*'s ſhadow but collect, that the original is a man, and not a brute; but they could not hence make any diſcovery of what manner of man he is, nor know any thing of his virtues, or his thoughts, or his intention, nor conſequently have that notion of him, that I (purſues *Euſebius*, turning to him, and a little ſmiling on him) do harbour and cheriſh, who having the happineſs to converſe with him, have the opportunity and the juſtice to admire him. Thus, where I formerly ventured to call the world God's ſhadow, I did not forget, how imperfect a picture a ſhadow is wont to be: and though this dark repreſentation, that God has vouchſafed men of himſelf in the univerſe, be ſufficient to convince us, that it was not made by chance, but produced by a powerful and intelligent being; the eternal power and God-head of the great author of nature, as the ſcripture ſeems to teach us, being manifeſted to attentive and rational conſiderers, in the viſible productions of his power and wiſdom; yet how ſhort and dim a knowledge muſt they have of him, that have no other than theſe corporal inſtructors? How many of his glorious attributes are there, for whoſe knowledge we muſt be beholden, rather to his written, than his created word? and how little will human intellects, without revelation, diſcover of that manifold wiſdom of God, which the ſcripture teaches us, *That even to the angels it muſt be made known by the church.* And if thoſe illuminated perſons, ſuch as *Moſes* and St. *Paul* himſelf, who had both extraordinary revelations from God, and intimate communion with him, confeſſed, that in this life they ſaw him but darkly, and, as it were, in a glaſs; ſure the dim light of mere nature will give us but extremely imperfect, and detracting ideas of him, whom the like limitedneſs of our nature will allow us to know but very imperfectly, in heaven it ſelf; though, as we ſhall there ſee him face to face, our apprehenſive faculties will as well be enlarged, as the dazzling and raviſhing object be diſcloſed. Ephes. iii. 10.

BUT, (ſays *Euſebius*) though I forget, that I am not in the pulpit, I hope you remember, that I told you at firſt, how little I pretended theſe kind of reflections would endure a rigorous philoſophical examen; and that I am not ſo indiſcreet, as to expect, that they ſhould work conviction in an infidel, though I hope they may excite good thoughts in a believer.

THESE laſt words of our friend being not followed by any other; *Lindamor*, having waited a while to aſcertain himſelf, that *Euſebius* had ended his diſcourſe, began another, by ſaying:

I PERCEIVE, *Euſebius*, with much more ſatisfaction than ſurprize, that the ſame ſubject, and at the ſame time, did, as it was fit, ſuggeſt very differing conſiderations to you and me; for whilſt your ſhadow afforded you the riſe of ſublime ſpeculations, I was making but a moral reflection upon mine: for taking notice, (continues he,) that the ſhade my body projected, near noon, was almoſt as much ſhorter than it, as in the morning it was longer, prompted me to think, how fooliſh it were for me, who know by ſure ways of meaſuring my own ſtature, that it is moderate enough, not to be either proud of, or complained of, ſhould imagine, that I am either as tall as a giant, or as low as a dwarf, becauſe I ſee my ſhadow either exceeding long, or extremely ſhort. And I was further conſidering, purſues *Lindamor*,

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Lindamor, that if philoſophers, as well as the vulgar, have rightly called fame or glory the ſhadow of virtue, it would be as irrational to eſtimate one's ſelf not by the teſtimonies of one's conſcience, which is the authentick ſtandard of intrinſick worth, but by the fickle opinions of others, (which oftentimes flatter, and oftener detract) but very ſeldom give a juſt and impartial eſtimate of merit: the fame may have its increaſe and decrements, whilſt the perſon continues the ſame, and loſes nothing of ſubſtance with the ſhadow. And for a man, that ſhould examine himſelf, and judge of himſelf by his own deſigns, and actions, not other men's words, to ſuffer himſelf to be puffed up by vulgar applauſe, or dejected by unmerited cenſures, were to miſtake a ſhadow for a ſtandard.

DISCOURSE VII.

Upon a fall occaſioned by coming too near the river's brink.

IT was not long after this, that *Eugenius* chancing to ſpy a little nook, which ſeemed to promiſe him a more convenient ſtation for his angling, he invited *Lindamor* to ſhare the advantage with him, and began to walk thitherward along the river's brink, which the abundant moiſture of the waters, that glided by it, had adorn'd with a pleaſant verdure; but he had not marched very far, when chancing to tread on a place, where the courſe of the water had worn off the bank, and made it hollow underneath, he found the earth falter under him, and could not hinder his feet from ſlipping down with the turf that betrayed him; nor could he have eſcaped ſo, had not his endeavours to caſt the weight of his body towards the bank been aſſiſted by *Lindamor*, who, though not ſo near the brink as to be in danger, was not ſo far off, but that he was able to catch hold of him, and to draw him to the firm land. The noiſe, that *Lindamor* made, when he ſaw his friend falling, quickly drew *Euſebius* and me thither; where, after I had a while made my ſelf merry with the diſaſter, I found to have been ſo harmleſs; *Euſebius* (who arrived there a little later) aſked him how he came to fall; and *Eugenius* anſwering, that he thought he had trod upon firm ground, becauſe he ſaw the bank look to the very edge, as if it differed not from the reſt of the field, which it terminated; *Euſebius* took occaſion from thence to tell him, You may from this take notice, that it is not ſafe travelling upon the confines of what is lawful, and what is ſinful, no more than upon the borders of two hoſtile nations: when we ſuppoſe, that thus far we may go towards that which is ſinful, without committing it, we are wont with more boldneſs than conſiderateneſs to conclude, that we need not ſcruple to venture, or rather that we ſhall run no venture, having firm footing all the way. But it is much to be feared, that when we allow our ſelves to come as far as the utmoſt verge of what is lawful, and to do that, which, in the caſuiſt's language, is *tantum non* to ſin, the natural proclivity of our minds to evil, which carries them downwards, as weight does our bodies, will ſome time or other make us find hollow ground, where we preſume to find it firm. He that to-day will go towards ſin as far as he thinks he may, is in danger of going to-morrow further than he ſhould; and it is far more eaſy for him to be ſecure than to be ſafe, that walks upon the brink of a precipice. He was a wiſe man, that as ſoon as he had forbidden his ſon to enter into the path of the wicked, and to go in the way of evil men, ſubjoins, as the beſt courſe to conform to the preſcription, Avoid it, paſs not by it, turn from it, and paſs away. God's indulgence leaves us a latitude to comply with our infirmities, and neceſſities, and to give us opportunities of exerciſing a pious jealouſy over our ſelves, and of ſhewing how much we fear to offend him. But a wary Chriſtian will ſay in this caſe, as St. *Paul* did in almoſt a like, *all things are lawful for me, but all things are not expedient*: and he muſt often go further than he can with prudence, that will always go as far as he thinks he can with innocence.

DISCOURSE VIII.

Upon the good and miſchief that rivers do.

THIS diſcourſe being ended, we all, as it were, by common conſent, applied our ſelves again to proſecute the ſport that had invited us to the river: but we had not angled very long, before we were diſturbed by a loud and confuſed noiſe, which we ſoon diſcovered to proceed from a ſhip, that, together with ſome barges, and other leſſer boats, were, by the help of a favourable breath of wind, ſailing up the river towards *London*. The ſight of theſe laden veſſels, together with the proſpect of the *Thames*, which, (as it happened in that place) ſeemed, in various windings and meanders, wantonly to fly, and to purſue it ſelf: this ſight, I ſay, together with the rich and flouriſhing verdure, which the waters, in their paſſage, beſtowed upon all the lands, that were on either ſide any thing near their banks, invited *Eugenius* to fall upon the praiſes of that excellent river, which not only imparts fertility and plenty here at home, by inriching all the places that have the advantage to be near it; but helps to bring us home, whatever the remoter parts of the world, and the Indies themſelves, whether eaſt or weſt, have of rare or uſeful.

LINDAMOR, having both applauded and recruited theſe commendations, Methinks, ſays he, that amongſt other good things, wherewith this river furniſh us, it may ſupply us with a good argument againſt thoſe modern Stoicks, who are wont, with more eloquence than reaſon, to declaim againſt the paſſions, and would fain perſuade others, (for I doubt whether they be ſo perſuaded themſelves) that the mind ought to deal with its affections, as *Pharaoh* would have dealt with the Jews-males, whom he thought it wiſe to deſtroy leſt they might, one day, grow up into a condition

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condition to revolt from him. But, becauſe the paſſions are (ſometimes) mutinous, to wiſh an apathy is as unkind to us, as it would be to our country, to wiſh we had no rivers, becauſe (ſometimes) they do miſchief, when great or ſudden rain ſwells them above their banks.

WHEN I conſider, (ſays *Euſebius*) that of the immaculate and divine lamb himſelf, it is recorded in the goſpel, that *he looked round about, upon certain Jews, with indignation, being grieved for the hardneſs of their hearts*; ſo that two paſſions are aſcribed to Chriſt himſelf in one verſe: and when I conſider too the indifferency (and conſequently the innocence) of paſſions in their own nature, and the uſe, that wiſe and virtuous perſons may make of them, I cannot think we ought to throw away (or ſo much as wiſh away) thoſe inſtruments of piety, which God and nature has put into our hands; but am very well content we ſhould retain them, upon ſuch conditions, as *Abraham* did thoſe domeſticks he bought with his money, whom, the Scripture tells us, *he both circumciſed and kept as ſervants.*

BUT, (continues *Euſebius*) as I do not altogether diſallow *Lindamor*'s compariſon between rivers and paſſions, ſo he muſt give me leave to add this to it, that as rivers, when they over-flow, drown thoſe grounds, and ruin thoſe huſbandmen, which whilſt they flowed calmly betwixt their banks, they fertilized and enriched; ſo our paſſions, (when they grow exorbitant and unruly) deſtroy thoſe virtues, to which they may be very ſerviceable whilſt they keep within their bounds.

INSTANCES of this truth, (purſues *Euſebius*) are but too obvious. It is ſaid, that valour is anger's whetſtone; and our being counſelled by the apoſtle, *to be angry and not to ſin*, argues that paſſion not to be incompatible with innocence, whilſt it is confined within the limits of moderation. But when once anger is boiled up into rage, or choler into an habitual fury, or appetite of revenge, it makes more havock in the world than beaſts and inundation: the greateſt part of thoſe rivers of blood, that are ſhed in battles, (though ſpilt by anger) do rather irritate than appeaſe the unnatural thirſt of that inſatiate fury: the burning of cities, the ſinking of fleets, and the deſolations of provinces, and of kingdoms, make but part of the tragick effects of this inhuman paſſion, when it once thoroughly poſſeſſes thoſe, that wield ſcepters, and handle ſwords.

I WILL not tell *Lindamor*, that even that nobleſt and beſt of paſſions, love, as gentle and amiable as it appears, when once it comes to degenerate by growing unruly, or being miſplaced, is guilty of far more tragedies than thoſe, that have the fortune to be acted on theatres, or to furniſh the writers of romances; and that which (perchance at firſt) ſeems to be but an innocent love, being not duly watched, and regulated, may, in time, grow to diſobey, or deceive parents, to violate friendſhips, to ſend challenges, and fight duels, to betray the honour of harmleſs virgins, and of the nobleſt families, to rebel againſt kings, procure the ruin of monarchies and commonwealths; and, in a word, to make thouſands miſerable, and thoſe it poſſeſſes moſt of all, and thereby to bring credit to, if not alſo to ſurpaſs, the fictions of poets, and the fabulous ſtories of romances.

AND as for the deſire of excelling others, as great and noble things as it makes men undertake, whilſt it aſpires only to a tranſcendency in virtue, and in goodneſs, when that paſſionate deſire, by making men too greedy of ſuperiority in fame and power, degenerates into ambition; how many vices are uſually ſet at work by this one paſſion! The contempt of the laws, the violation of oaths, the renouncing of allegiance, the breach of leagues and compacts, the murder of one's neareſt relations, (if they be more nearly related to a crown) and all the other crimes and miſeries, that are wont to beget or attend civil wars, are the uſual as well as diſmal productions of this aſpiring humour in a ſubject. Nor does it leſs miſchief when harboured in a prince's breaſt; for the undoing of his own people, the ſubverſion of his neighbour's ſtates, the ſacking of cities, the ſlaughter of armies, the diſpeopling of ſome provinces, and the peopling of others with widows and orphans, are ſacrifices, that are more frequently offered up to ambition, than able to ſatisfy it. For what can quench his thirſt of rule and fame, or hinder the attempts, to which it ſtimulates him, that can find in his heart to deſtroy armies, and ruin provinces, only that he may be taken notice of to be able to do ſo?

CERTAINLY (ſubjoins *Euſebius*) he knew very well the frame of human ſpirits, that ſaid by the pen of an Apoſtle; *From whence comes wars and brawlings among you? Come they not hence, even of your luſts that war in your members.* And I doubt not, whether plagues, wars and famines have done more miſchief to mankind, than anger and ambition, and ſome other inordinate paſſions; for theſe do frequently bring upon men thoſe publick and other fatal calamities, either as judgments, which they provoke God to inflict, or as evils, which as proper conſequents naturally flow from thoſe miſchievous practices, to which unbridled paſſions hurry the criminally unhappy perſons they have enſlaved. James iv. 1.

WHEREFORE, (concludes *Euſebius*, caſting his eyes upon *Lindamor*) as the uſefulneſs of a river hinders us not from making good the banks, and, if need be, making dams, to confine it within its limits, and prevent its inundations; ſo the uſefulneſs of the paſſions ſhould not hinder us from watchfully employing the methods and expedients afforded us by reaſon and religion, to keep them within their due bounds, which they ſeldom overflow without ſhewing, to our coſt, that, as it is obſerved of fire and water, they cannot be ſo good ſervants, but that they are worſe maſters.

DISCOURSE IX.

Upon the comparing of lands, ſeated at different diſtances from the river.

THIS laſt diſcourſe, to which the river had afforded the occaſion, inviting me to ſurvey as much of it, as was within my view, a little

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little more attentively, gave me the opportunity of taking notice of a manifeſt difference betwixt the lands that lay near it, and thoſe whoſe ſituation was remoter from it; and having acquainted *Euſebius* with what I had obſerved, which his own eyes could not but preſently bear witneſs to; One (ſays he) that ſhould only conſider how ſwiftly this ſtream runs along theſe flowery meadows, and how great a quantity of water paſſes through them, and from them, towards the ſea, would be apt to conclude, that certainly theſe grounds retain none of the waire, which runs from them ſo haſtily, and ſo plentifully; eſpecially ſince we can ſee no channels, nor other manifeſt inlets, and receptacles, that ſhould divert and retain the fugitive water, ſo that the grounds confining on the river muſt be but little advantaged by its neighbourhood. But, (continues *Euſebius*) though theſe grounds have not any patent paſſages, whereby to derive water and fatneſs from the river, and therefore muſt ſuffer the greateſt part of it to run by them undiverted; yet ſtill ſome of the cheriſhing and fertilizing moiſture is from time to time ſoaked in by the neighbouring ground, and (perhaps by blind pores and crooked channels) ſo diſperſed thorough the whole fields, that they have thereby water, and in that vehicle fertility conveyed to them; which you will not doubt, if you do but with me take notice, how much the lands, that lie on both ſides near the courſe of the river, are more verdant, and flouriſhing, and more rich, than thoſe leſs happy grounds, to whom their remoteneſs denies the advantage of ſo improving a neighbourhood.

THUS (reſumes *Euſebius*) many a pious perſon, that is an aſſiduous attendant on the means of grace, and has a care to place himſelf, as it were, in the way, by which the ordinances of God, eſpecially thoſe of reading and expounding of the Scriptures, are wont freely and copiouſly to flow, is (eſpecially upon any fit of melancholy, or diſtreſs of mind) apt to be extremely diſcouraged from proſecuting that courſe of duties; and by looking upon the little, that he remembers of ſo many excellent ſermons as he has heard, he is often inclined to conclude, not only he has loſt all the good ſermons, that he has heard already, but that at leaſt for ſuch as he, there is little to be expected from from them for the future.

BUT though to loſe ſo much of a thing, ſo precious as the doctrine of ſalvation, be that, which is oftentimes a fault, and always an unhappineſs; yet it is a far leſs miſchief to forget ſermons than to forſake them; the one may be but an effect of weak memory, the other is that of a depraved will, perverted by lazineſs, impatience, or ſome greater fault. We ſhould ſcarce allow it for a rational proceeding, if one in a conſumption, or diſentery, becauſe he grows not fat with feeding, ſhould reſolve to renounce eating and drinking.

BUT this (ſays *Euſebius*) is not that, which I chiefly intended: for pious, but melancholy perſons, are oftentimes too partial againſt themſelves, to be competent judges of their own eſtate; they ſeem not to forget any ſermon ſo much, as that charity ſhould begin at home; and they are much more careful not to accuſe any body wrongfully than themſelves: though they might remember, that in the eſtimate of Chriſt himſelf, all grounds are not equally fruitful, that are good; ſome bringing forth hundred, ſome ſixty, ſome but thirty fold, and yet to all he vouchſafes the title of good. And though, as mad men, that have quite loſt their wits, ſeldom or never complain of the want of them; ſo thoſe, that have forfeited, or are devoid of grace, rarely bemoan themſelves of the weakneſs of it. And it is no mean ſign of proficienty in piety, to be apt to deplore one's unproficiency in piety. It is true, that preaching is not always, and I fear not ſo much as often, the ſavour *of life unto life*; the perverſeneſs of the hearers making it but too frequently the ſavour *of death unto death*. But yet, ſpeaking in the general, though it aggravate the ſins committed in ſpite of it, yet it uſually hinders many others from being committed; and he, that twice a week is told of God, and duty, and heaven, and hell, has his conſcience more awaked, than he, that never hears of any of theſe things. And if you but compare one of theſe deſpondent Chriſtians, we are conſidering, with the careleſs ſenſualiſts, that fly a rouzing ſermon, as they ſhould do what it would deter them from; you will eaſily diſcern a ſufficient diſparity between them, to invite you to conclude, that the inſtructiveneſs of preaching may, like the moiſture of the river, be conveyed but by little and little at a time, and by unperceived paſſages, and yet be able to impart fertility. For though much run by, yet commonly ſomething will ſtick; which we may ſafely conclude, if though we can diſcern it no other way, it diſcloſe it ſelf by the effects. For it is not always to thoſe, that remember the moſt of them, that ſermons do the moſt good, as water retained in ponds makes not the bottom flouriſhing, but the banks; and the efficacy of a ſermon is better to be collected from the impreſſion it has on the underſtanding and affections, than from that it leaves on the memory: whether we retain the particulars faithfully or no, and carry them home with us; yet if a ſermon leave us devouter than it found us, if we go from God's ordinances, with a love to them, and a reliſh of them, and a purpoſe to frequent them, we may be deſpondents, but are not altogether non-proficients: that incorruptible ſeed, by which we are regenerated, being once thrown into an honeſt heart, may, as our Saviour intimates, grow up we know not well how, and though perhaps by inſenſible degrees, yet at length attain maturity. To diſpatch, (concludes *Euſebius*) whether or no a man can orderly repeat all the particulars that compoſed the ſermon, it does him good, if it either makes him good, or keeps him ſo; and its operation is to be eſtimated, not ſo much by what we remember, as by what we reſolve.

WHAT you have been ſaying, (ſubjoins *Lindamor*, when he perceived that *Euſebius* had done ſpeaking, ſuggeſts to me a reflection, that till now I did not dream of; and though

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it differ from that, wherewith you have been pleaſed to entertain us, yet becauſe it is applicable to the ſame purpoſe, and occaſioned by the ſame river, I ſhall without ſcruple, though, after your diſcourſe, not without bluſhes, tell you, that it is this; I, among many others, that live near it, have often reſorted in hot weather to this river, to bathe my ſelf in it; and after what I have been hearing, I now begin to conſider, that though incomparably the greater part of the river run by me, without doing me any good, and though when I went out of it, I carried away little or none of it with me; yet whilſt I ſtayed in it, that very ſtream, whoſe waters run ſo faſt away from me, waſhed and carried off whatever foulneſs it might find ſticking to my ſkin; and beſides, not only cooled me, and refreſhed me, by allaying the intemperate heat, that diſcompoſed me, and made me faint, but alſo helped me to a good ſtomach for ſome while after.

THUS (reſumes *Lindamor*) I have ſometimes found, that a moving ſermon, though it did not find me qualified to derive from it the advantages it queſtionleſs afforded better auditors; and when I went from it, I found I had retained ſo little of it, that it ſeemed to have almoſt totally ſlipt out of my memory, yet the more inſtructive and pathetick paſſages of it had that operation upon me, as to cleanſe the mind from ſome of the impurities, it had contracted by converſing to and fro in a defiling world, without ſuffering pollutions to ſtay long, and ſettle, where they began to be harboured: and beſides, I found that a courſe of ſuch ſermons, as I have been mentioning, did oftentimes (and if it had not been my own fault, would have always done ſo) both allay thoſe inordinate heats, that tempting objects are but too apt to excite; refreſh my drooping ſpirits, that continually needed to be revived, and raiſe in me an appetite to the means of grace, which are piety's (and conſequently the ſoul's) true and improving aliments. So that, (concludes *Lindamor*) though I ſeldom let ſermons do me all the good they may, and ſhould, yet I dare not forſake them, becauſe I forget them; ſince it is to do a man ſome good, to make him leſs bad than he was, and to give a value and inclination for the means of growing better than he is.

DISCOURSE X.

Upon a fiſh's running away with the bait.

THIS reflection of *Lindamor*'s was ſoon followed by another of the ſame gentleman's, who ſeeing many fiſhes riſe one after another, and bite at *Eugenius*'s bait, which he let them ſometimes run away with, that he might be the ſurer to be able to draw them up, as he afterwards did ſeveral of them; See, (ſays *Lindamor*, as one of the fiſhes had juſt ſwallowed the hook) how yonder ſilly fiſh, having at length ſeized the beloved bait he has been courting, poſts away with it as his obtained wiſh, little dreaming of being himſelf taken. Thus (continues the ſame ſpeaker) when greedy mortals have an opportunity to obtain forbidden things, they joyfully run away with them as the goods they aimed at, and when they fondly think they have caught, they are ſo; and whilſt they imagine themſelves to carry away a booty, they become a prey: for that he is, in his judgment that never errs, who, whatever he gets into the bargain, loſes himſelf.

THE Scripture (ſubjoins *Euſebius*) mentions, among other properties of vice, that which it calls the deceitfulneſs of ſin. And the wiſe man tell us, that wine is a mocker; and it may be one of the reaſons of theſe expreſſions, that when we think our ſelves poſſeſſed of a ſinful pleaſure, we are indeed poſſeſſed by it, as demoniacks are poſſeſſed by the devil, who ſerves many other ſinners, though leſs perceivedly, as he ſerves witches, whom he gets the power to command, by ſeeming to obey them, and to comply with their criminal deſires: and, if we compare this with what I was juſt now obſerving to you, on the occaſion of the counterfeit fly, we may add, that even when ſin ſeems the kindeſt and moſt obſequious to us, and to anſwer, if not exceed our deſires, our caſe may be but like the Canaanitiſh general's, who, though he had milk brought him by *Jael* inſtead of the water he only requeſted, was but thereby invited *to ſleep the ſleep of death*, and to have his fears more ſurpaſſed than his deſires had been. Judges iv. 29.

BUT, (purſues *Euſebius*) this may ſupply us with another reflection; for though this fiſh ſeems to have devoured the hook and bait it ſwallowed, yet in effect it is taken thereby: ſo the devil, when he had played the ſerpent and the lion, when he had brought the Jews and Gentiles to conſpire againſt their common Saviour, and had made *Herod* and *Pilate* friends, to make them joint enemies to Chriſt, and when by theſe means he ſeemed to have obtained his end, by employing their hands to kill the formidableſt of all his enemies; this purſued prey deſtroyed the ſeeming conqueror; and death appearing to ſwallow the Lord of life was, if I may ſo ſpeak, choaked by the attempt, ſince he not only was quickly able to ſay in the Apoſtle's triumphant language, *O death, where is thy ſting? O grave, where is thy victory? but did by death conquer him that had the power of death, that is, the devil:* nay, and made all his followers ſo much ſharers in the advantages of his conqueſt, as by the ſame way (which we are informed by the ſame text) to deliver thoſe, whom the reſtleſs fear of death perpetually kept from reliſhing the joys of life. 2 Cor. xv. 15. Heb. ii. 14, 15.

DISCOURSE XI.

Upon a danger ſpringing from an unſeaſonable conteſt with the ſteerſman.

THIS diſcourſe being ended, *Eugenius*, who was looked upon by us all as the moſt experienced as well as concerned angler among us, deſcrying at a good diſtance a place, which he judged more convenient for our ſport, than that we there were in, where the fiſh began

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gan to bite but ſlowly; he invited the company to this new ſtation: but when we were come thither, finding in a ſhort time, that either it was ill ſtocked with fiſh, or that the ſeaſon of their biting in the places thereabouts was over, he thought it concerned him to provide us ſome better place. And accordingly, whilſt we were yet, by the pleaſure of mutual converſation, endeavouring to keep the fiſhes ſullenneſs from proving an exerciſe to our patience, he walked along the river, till he lighted upon a youth, that by his habit ſeemed to belong to ſome boat or other veſſel; and having inquired of him, whether he could not be our guide to ſome place where the fiſh would bite quick, he replied, that he eaſily could, if we would take the trouble of coming to a place on the other ſide of the river, which his maſter, who was a fiſher-man, had baited over night, and would queſtionleſs let us make uſe of for a ſmall gratification. *Eugenius*, being very well content, called away the company, which were led by the youth to a boat belonging to his maſter; into which being entered, the old man, who was owner of the boat, hoiſted up ſails, and began to ſteer the boat with one of his oars, to a place he ſhewed us at a good diſtance off; but did it ſo unſkilfully, that ſince a mariner of his age could ſcarce miſtake ſo groſly for want of experience in the river, we began to ſuſpect, that he had too plentifully taſted a far ſtronger liquor than that which was the ſcene of his trade: and as the old man was half drunk, ſo the youth appeared to be a mere novice, both which we had quickly occaſion to take notice of. For ſome clouds that were gathering out of the ſea, paſſing over our veſſel, raiſed in their paſſage, as is uſual enough, a temporary wind, that to ſuch a ſlight boat as ours was might almoſt paſs for a kind of ſtorm: for then the old man gave his directions ſo ill, and the youth was ſo little able to execute them punctually, that two of the company, offended at their unſkilfulneſs, began by angry and unſeaſonable expoſtulations and clamours to confound the already diſordered boat-man; and being got up, with no ſmall hazard to the boat, they would perchance, by croſſing the watermen in their endeavours, have made it miſcarry, had not *Lindamor*, whoſe travels had made him well acquainted with ſuch caſes, earneſtly requeſted them to ſit ſtill, and let the watermen do their own work as well as they could; affirming, that he had ſeen more than one of thoſe eaſily over-ſet boats caſt away, by the confuſed and diſagreeing endeavours of the watermen and paſſengers to preſerve it. This counſel was thought very reaſonable, ſince the greater the wind was, and the leſs the ſteerman's dexterity, the more neceſſary it appeared, that we ſhould be orderly and quiet, and by leaning our bodies ſometimes one way, and ſometimes another, as occaſion required, do what in us lay to keep the veſſel upright: and herein we were ſo proſperous, that ſoon after the cloud was paſſed, and the ſhower it brought with it was over, the wind grew moderate enough to allow us to make ſome calm reflections on what had happened. This *Lindamor*, from the thanks that were given him for his advice, took occaſion to do in theſe terms: Since ſtateſmen and philoſophers are wont to compare a commonwealth to a ſhip, I hope the reflection ſuggeſted to us by what had juſt now happened, will be the eaſier pardoned. The ſkill of ruling nations is an art no leſs difficult than noble; for whereas ſtatuaries, maſons, carpenters, and other artificers work upon inanimate materials, a ruler muſt manage free agents, who may have each of them intereſts or deſigns of their own, diſtinct from thoſe of the prince, and many times repugnant to them: and the prizes, that are contended for in government, either are, or (which is in our caſe all one) are thought, ſo valuable, and the concurrents are ſo concerned, and conſequently ſo induſtrious to drive on each his own deſign, that without mentioning any of thoſe many other things, which make good government difficult, theſe alone may ſuffice to make it more our trouble than our wonder, that the rulers of ſtates and commonwealths ſhould oftentimes miſ-govern them. But the publick infelicities of declining ſtates are not always wholly due to the imprudence of the ruler, but oftentimes thoſe, that moſt reſent ſuch imprudency, even by thoſe very reſentments increaſe the publick diſorders they appear ſo much troubled at; and it may be a queſtion, whether it be more prejudicial to commonwealths, to have rulers, that are mean ſtateſmen, than to have a multitude of ſubjects, that think themſelves to be wiſe ones, and are forward to cenſure what is done by their magiſtrates, either becauſe it is done by their ſuperiours, or becauſe it is not done by themſelves.

YET it may well be doubted, (ſays *Eugenius*) whether the reverence and ſubmiſſion we owe to ſenates, or princes extend to our very reaſons, and our inward thoughts: for the right, and the ſkill to govern, are two very diſtinct things; nor does the one confer the other. A crown, how precious ſoever, adorns but the outſide of the head, without enriching the inſide; and its ſplendour will ſcarce dazzle a wiſe beholder's eyes, though it but too often does theirs that wear it. No, the tribunal of reaſon has a juriſdiction, that reaches to thrones themſelves; and what you well obſerved juſt now, concerning the difficulty of avoiding faults in government, will, I preſume, make you think it excuſable, if I confeſs, that I think ſovereigns do now and then do, what you confeſs it is ſo hard for them to avoid doing; nor is it more a breach of loyalty, not to think a weak governour a prudent one, than not to think him tall, or ſtraight, or ſharp-ſighted, if nature have made him low, or crooked, or purblind. A ſenate or a monarch may indeed command my life and fortune; but as for my opinions, whether of perſons, or things, I cannot in moſt caſes command them my ſelf, but muſt ſuffer them to be ſuch, as the nature of the things I judge of requires; and therefore, the thinking all things done with wiſdom, that are done by men in power, is too great an impoſſibility to be a

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duty; and beſides, it would leſſen the merit of obedience, which otherwiſe would not appear to be paid to the authority of the magiſtrate, ſince we readily obey the injunctions of lawyers and phyſicians, as long as we think them prudently framed for our good, though we acknowledge not theſe perſons to have any right to command us.

BUT though (continues *Eugenius*) I take reaſon to be ſo ſupreme a thing, that as even the greateſt prince's actions ſhould be regulated by it, ſo they may be judged by it; yet I allow lawful authority a juriſdiction over my actions, that I deny it over my opinions: and though I can obey the orders, that have the impreſſes of wiſdom, as well as the ſtamp of authority, with more hope and alacrity, yet I can obey thoſe, wherein I think power is unguided by prudence, with no leſs punctualneſs and fidelity. I would not reſiſt a magiſtrate, when I cannot eſteem him; and though I dare diſcern folly even in the greateſt princes, yet I can reverence authority in the weakeſt.

I KNOW *Eugenius* too well (ſays *Lindamor*) not to believe him. But though I confeſs, that to do what you ſay, is to do much, and to do that, which I fear is not uſually done; yet methinks it were well if we did ſomewhat more. For whereas moſt human actions, eſpecially about matters political, are attended with great variety of circumſtances, according to ſome or other of which, they may be differingly conſidered, and eſtimated; as it is not very difficult to make many, if not moſt actions appear politick or unwiſe, according as they are cloathed with thoſe of their circumſtances, that may be applied to excuſe them, or with thoſe, that are fit to diſcommend them; ſo I would take a care to put the favourableſt conſtructions on thoſe publick counſels, that are capable of more conſtructions than one, and uſe the parents of my country, as *Noah*'s two dutiful children did their diſtempered father, whoſe nakedneſs when they had once diſcovered, they covered too; and that in ſuch away, as ſhewed they were unwilling to ſee more of it, than was neceſſary to enable them to hide it. And I ſay this, (continues *Lindamor*) with relation to *Eugenius*, and ſuch as he; for as to the vulgar, who yet make up the far greateſt and loudeſt part of thoſe, that would intrude themſelves into ſtate-affairs, upon the pretence of their being ill managed by their ſuperiours; I cannot but think, that whatever the courſe of affairs be, theſe cannot but be incompetent judges of their being politick, or the contrary. For to judge of things barely by ſucceſs, were ſomewhat to forget, that there is a ſupreme and abſolute diſpoſer of events, and has been a practice always rejected by the wiſe, as both diſcouraging wiſdom, and affronting it. And as for the counſels, by which indeed the prudence or imprudence of publick actions is to be eſtimated, the vulgar is rarely admitted to have ſuch a proſpect into the true ſtate of affairs, as is requiſite to enable them to judge of the expedience or unadviſedneſs of them, being unacquainted with the frame and motives of the prince's counſels and deſigns. Ordinary men may often think that imprudent, whilſt they conſider it only in it ſelf, which its congruity to the reſt of the prince's deſigns may make politick enough; and a private whiſper, or the intimation from an unſuſpected ſpy, or an intercepted letter, or divers other things unperceived, and perhaps undreamt of, by thoſe, that are not of the ſtate-cabal, may make it wiſe to do ſeveral things, which to thoſe, that look only at the actions, without knowing the motives, may appear unpolitick, and would indeed be ſo, were it not for theſe reaſons, which yet ought to be as little divulged as diſobeyed. So that the people's forwardneſs to quarrel with the tranſactions of their prince, is uſually compounded of pride and ignorance, and is moſt incident to thoſe, that do not ſufficiently underſtand either ſtate-affairs or themſelves; and whilſt they judge upon incompetent information, even when their ſuperiours are in the fault, they may be ſo, for cenſuring them.

I muſt not now diſpute, (ſays *Euſebius*) whether ſuch as you, gentlemen, whom their conditions, parts and opportunities qualify to diſcern the intereſts and deſigns of princes, may not be allowed to judge of their counſels, and ſee their errors; as our late aſtronomers, being aſſiſted with good glaſſes, are allowed to tell us, that they diſcern ſpots even in the ſun it ſelf. But, certainly, the ambition of pragmatical inferiours to make themſelves ſtateſmen, upon pretence, that thoſe, who ſit at the helm, do not govern it as wiſely as theſe would do, if they were in the ſame places, is a fault no leſs prejudical to any ſtate, than epidemical in ſome of them. For whilſt the goverment is thus decried, the ſame diſadvantageous repreſentations embolden ſtrangers and foreigners to attempt the ſubverſion of a ſtate, and make the deſpondent ſubjects deſpair of preſerving it; little conſidering, that there are ſcarce ever any imprudences in a government, that can prove any thing near ſo prejudicial to the generality of the ſubjects, as would the ſubverſion of it, whether by foreign conqueſt, or by inteſtine jars; ſuch changes ſeldom doing leſs than entail upon unhappy countries the fears and miſchiefs of war. And that though it be granted, that the right of governing does not confer the ſkill, yet it is much better to ſtick to the former, than oppoſe or deſert it, becauſe it wants the latter: for a right to a crown, is that, which for the moſt part manifeſtly belongs but to one, and is ſeldom plauſibly pretended to by above two or three; whereas the ſkill to govern is ſo undetermined, and ſo uncertain a thing, that men's innate pride and ſelf-love would incline almoſt every man to claim it for himſelf, eſpecially, ſince by challenging that, he might put for no leſs than ſovereignty. And in a ſtate thus abandoned to the craftieſt or the ſtrongeſt, there would never want diſturbing viciſſitude of governments, as well as governours, ſince whoever could get intereſt enough in the ſoldiery, or the multitude, would quickly deviſe and impoſe ſuch a frame of government, as may put the management of affairs into his and his party's hands, and give them the authority, that have the

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the power. But (reſumes *Euſebius*) I muſt remember, that not politicks, but divinity is my profeſſion, and therefore without enlarging upon the confuſion that is inevitable in a ſtate, where the right of governing being not heeded, or at leaſt not aſcertained, every man would pretend to counſel or command, and none would think himſelf bound to obey; I ſhall only mind you, that magiſtracy having been inſtituted by God for the good of mankind, we may in obeying our lawful magiſtrates, though perhaps leſs wiſe than we could wiſh them, not only participate the advantages naturally accruing from obedience to ſuperiours, but divers peculiar bleſſings, that God oftentimes vouchſafes to our obedience to his vicegerents, and his inſtitutions. Let ſubjects therefore (ſays *Euſebius*) wiſh for wiſe princes, but ſubmit to thoſe, the providence of God, and the laws of their country, may have given them: let us, if by any juſt way we be called to it, aſſiſt a prince with the wiſeſt counſels we can; if not, let us aſſiſt him to make the beſt of the unwiſe counſels he has taken, without adding our factiouſneſs or our paſſions to his miſgovernment; remembering, that, at leaſt in my opinion, to the happineſs of a commonwealth it is not only requiſite, that the prince know how to command well, but that the ſubjects obey well; and that even weak counſels, faithfully aſſiſted, and as much as may be rectified or repaired by thoſe, that are to execute them, may leſs prejudice the publick, than the forward and jarring endeavours of men, that perhaps would be wiſer rulers, if they had a right to be ſo. It may be (continues *Euſebius*) that affection and diligence in the publick ſervice may, in ſpite of the government's miſcarriages, prevent, or at leaſt retard and leſſen, the ruin of the ſtate. But however, (concludes he) it will be no ſmall ſatisfaction to an honeſt man, and a loyal ſubject, not to be conſcious to himſelf of having contributed to the publick calamities, either by his own provocations, or his factious indignation at the prince's faults. If a man have done his utmoſt to hinder the ruin he comes to be involved in, the publick calamity will be far lighter to him, being not clogged by private guilt; and he will ſupport the misfortune of it with far the leſs trouble, if he be to ſupport nothing elſe. Nay, ſince the ſervice we do to whatever prince is rightfully ſet over us, upon the ſcore of his being God's vicegerent, is ultimately directed to that ſupreme, and, as the ſcripture calls him, only potentate, whoſe magnificence is as inexhauſted as his treaſure; we may ſafely expect, that whatever prejudice we here ſuſtain upon the account of the prince's commands, will hereafter be advantageouſly conſidered to us in the reward of our obedience.

DISCOURSE XII.

Upon clouds riſing out of the ſea, and falling down in rain not brackiſh.

THIS diſcourſe had already laſted ſo long, that as well my unwillingneſs, that one theme ſhould detain us any longer, as my deſire to keep *Eugenius* from making any reply, which on ſuch an occaſion might, perchance, have begot ſome diſpute, made me forward to divert the diſcourſe, by inviting the company to take notice of a black cloud, that was coming towards us; which ſoon after, in its paſſage under the ſun, interpoſed betwixt our ſight and that glorioſeſt object of it. *Lindamor* then having a while attentively enough conſidered it, took thence an occaſion to ſay, This cloud, gentlemen, whenſoever it ſhall fall down in rain, will ſufficiently ſhew, that it was before but water, which whilſt it lay mingled with the reſt of the river, or ſea, whence it is exhaled, may be ſuppoſed as clear and limpid as any of the reſt; but now that the ſun has by its powerful beams elevated this water in the form of vapours, and drawn it near it ſelf, we ſee, it compoſes a cloud, which does no longer receive or tranſmit the light, but robs the earth of it, and eclipſes the ſun that raiſed it; and ſometimes too produces diſmal ſtorms of rain, and wind, and hail. Thus (purſues *Lindamor*) there are many, who while they continued in a low and private fortune, were as blameleſs as others; and yet, when by a peculiar vouchſafement of providence, they are raiſed from that humble ſtate to a conſpicuous height, they ſeem to have as much changed their nature as their fortune; they grow as much worſe than meaner men, as their condition is better than that of ſuch; and the principal things, by which they make their exaltation be taken notice of, are, the prejudice they do to their inferiours, and the ingratitude they excuſe towards that monarch of the world, that raiſed them above others. Of ſo perverting a nature is ſo high a ſtation, that the gaining of an earthly crown is very far from being a furtherance to the acquiring of an heavenly one; and many, whom an humble condition of life kept as innocent as lowly, are, by the higheſt advancement in point of fortune, impaired in point of morality; and theſe ſupreme dignities, which the ambitious world ſo fondly courts and envies, do ſo often manifeſt thoſe, that have attained them, to be unworthy of them.

I KNOW not whether *Eugenius* imagined, that *Lindamor* did in this diſcourſe make ſome little reflection upon what we had lately ſaid on the behalf of princes: but I afterwards ſuſpected, that it was partly to reply to this obſervation, as well as entertain the company with a new one, that he ſubjoined; as this cloud has furniſhed *Lindamor* with one reflection, ſo that, which lately brought us the ſhower of rain, whoſe marks are yet upon our hats, may ſupply us with another, which may ſhew, that themes of this nature are applicable to very differing purpoſes, according as one or the other of their circumſtances happens to be conſidered and employed: for as far (purſues he) as we can judge by the neighbourhood of the ſea, and by that cloud's being driven hither by a wind blowing thence, it conſiſted of the ſea-water raiſed in the form of vapours. But though the water of the ocean is ſalt and brackiſh, unpleaſant and unwholeſome, whilſt it lies there unelevated;

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yet that water, which has the advantage of being raiſed to the ſecond region of the air, appears, when it is turned into rain, to have left all its brackiſhneſs behind it, and proves both wholeſome for men's bodies, and fertilizing to their fields.

THUS (continues *Eugenius*) we ſometimes ſee, that men, who in a private condition were ſubject to divers vices, diveſt them, when they are advanced to the honour of putting on royal robes; as ſilk-worms leave their huſks behind them, when by acquiring wings they turn into (a nobler ſort of creatures) flying animals. As moſt men change, ſo ſome improve their minds with their condition, and ſeem to have miſbehaved themſelves in a lower ſtation; but becauſe they were born to a higher, and were, whilſt beneath it, detained out of their proper ſphere. And indeed, as a throne expoſes thoſe, that ſit on it to peculiar temptations to vice, ſo does it afford them peculiar engagements to virtue; as ſo elevated a ſtation is apt to make men giddy, ſo is it proper to make them circumſpect, by letting them ſee, that all the world ſees them: the ſublimity of ſuch a condition would make any ſoul, that is not very mean, deſpiſe many mean things, that too often prevail upon inferiour perſons. If princes have any ſenſe of ſhame and honour, it will be a great curb to them, to conſider, that, as there are too many eyes upon them to let their vices be ſecret, ſo their faults can as little eſcape cenſure as diſcovery; and men will be the more ſevere to their reputations, becauſe it is the only thing, wherein ſubjects can puniſh their ſovereigns. If they have any thing of generoſity in their natures, their very condition, by placing them above other objects, will make them aſpire to glory; and that is a miſtreſs, that even monarchs cannot ſucceſsfully court, but with great and good actions. And if they have withal a ſenſe of piety, they cannot but in gratitude to him, whoſe vicegerents they are, endeavour to promote his intereſts, that made them ſo; and ſo make themſelves as like him as they can, in his other attributes of clemency, juſtice, and bounty, as he has vouchſafed to make them in his power and authority. And beſides, that the actual poſſeſſion of an earthly crown leaves them nothing worth aſpiring to, but a heavenly one; the conſideration of the great advantages they have above other men of doing good, and the exemplarineſs and influence as well of their vices as of their virtues, will make them tremble at the thoughts of the account they muſt one day render of ſo many thouſands, perhaps of ſo many millions (of ſubjects) committed to their charge; if, as they are ſure it will be a great one, they ſhall not make it a good one. Nor (purſues *Eugenius*) is hiſtory altogether unfurniſhed with examples of thoſe, whom a throne has as well improved as dignified. *Saul* was not the only perſon, who, when he was created king, had another ſpirit, and became another man. That *Titus*, who was the head of it, was juſtly ſtyled the darling of mankind, though his virtue and nobleneſs did, more than his crown, keep the greateſt part of poſterity from taking notice of any thing in him, but an obligingneſs proportionate to his greatneſs; yet I find in ſome ancient writers, to whom truth was more dear than even this favourite of mankind, that before he came to that ſupreme pitch of human dignity, his courſe of life did not promiſe the Roman world the happineſs it derived from his government; his life, before he came to be Emperor, having not been ſo free from blemiſhes of luſt and blood: but that I may, in writing his character, invert what the Roman hiſtorian ſaid of one of his predeceſſors, and ſay, that *Titus* had been thought *indignus imperio, niſi imperaſſet*. And, without going as far as *Rome*, our own hiſtory affords us a *Henry* the fifth, who, before he came to the kingdom, was ſcarce thought worthy to live in it, and did ſo degrade himſelf to the practices of the meaneſt malefactors, that a judge, that was then his father's ſubject, was fain to uſe him at that rate; and yet this prince, as ſoon as he had ſeated himſelf in the throne, did as ſuddenly, as if the place it ſelf had ſome ſecret virtue to improve thoſe it admitted, behave himſelf as a perſon worthy of it; and not only conquered *France*, but, which was a nobler, as well as a more difficult victory, his own reſentments too, by preferring that judge, when king, that had impriſoned him, when prince; and evincing by ſo memorable an action, that he preferred virtue above himſelf, and renouncing the pleaſure of revenge, he ſcrupled not to promote one, whom he could not commend without condemning himſelf; were it not, that in this prince, according to what I was ſaying, the king was become another man than the ſubject. And perhaps, (concludes *Eugenius*, a little ſmiling) I could proceed to give you other examples enough to keep it from being improbable, that one main reaſon, why there are but few good princes, is, becauſe there are but few princes; were it not, that I ſee the waterman prepare to land us. And in effect, we are now come ſo near the place, where the fiſherman deſigned to ſet us aſhore, that whether or no *Lindamor* had a mind to return any thing to what *Eugenius* had ſaid, it would then have appeared unſeaſonable, either to reſume the debate, or proſecute the diſcourſe.

1 Sam. x. 6, 9.

DISCOURSE XIII.

Upon drawing the boat to the ſhore.

WHEN we were now come to the place, where we were to be landed, leſt the boat ſhould be carried away by the ſtream before we could ſtep aſhore, the owner of it reached out his long pole, and by means of the crook, taking faſt hold of the bank, he drew the pole towards him with all his might, and thereby brought the boat to ſhore. This endeavour of the water-man's, and the effect of it, inviting *Euſebius* to ſmile a little, gave me the curioſity, as ſoon as we were landed, to inquire, why he did ſo. It is almoſt as ordinary, (anſwers *Euſebius*) for men to think themſelves

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themſelves wiſer than God, as it is impoſſible for them really to be ſo. Thoſe, that ſtudy nothing but to obtain their ends, and that ſcruple at nothing they judge conducive to them, do oftentimes lay their deſigns and plots with ſo much artifice and ſubtilty, that they do not doubt, that, whatever may become of God's deſigns, and of his promiſes, and threats, thoſe, which themſelves have laid ſo politickly, cannot but ſucceed. And even pious and well-meaning perſons, that have the opportunity to diſcern the politick ways, that theſe men take to compaſs their ends, are oftentimes tempted to needleſs fears, that divine providence will be puzzled and diſtreſſed by them; and to think, that, for reaſons ſecret, though juſt, providence may be put by theſe men's craft to play an after-game in the world to come. But in ſuch caſes, it often fares with theſe grand deſigners, as it did juſt now with our water-man: he had faſtened his grapling-iron to the ſhore, and putting to his utmoſt ſtrength, did ſo forcibly endeavor to draw it towards him, that one, that did not know that the ſhore was fixt, might expect this luſty fellow's endeavours capable to put into motion whatever he ſo forcibly drew towards him: but the ſhore being fixt, and immoveable, inſtead of making that come to him, his very ſtrainings drew him and his boat to that. Thus the contrivers of the proud pile of *Babel*, whereby they meant (not as moſt imagine, to ſecure themſelves againſt a ſecond flood; the text being ſilent as to that aim, and a plain being a very improper place for ſuch a purpoſe, but) to make themſelves a name, and prevent diſperſion; theſe ambitious contrivers, who had laid their plot ſo hopefully, that they had engaged no leſs than mankind, and who probably had deſigns as raiſed as their intended fabrick, ſince thoſe expreſſions of him, that knew their hearts, (*And this they begin to do, and now nothing will be reſtrained from them, which they have imagined to do*) ſeemed, methinks, to warrant my conjecturing, that thoſe had deſigns very aſpiring, that intended but to make a riſe to their ſoaring flight of a tower, whoſe top ſhould reach unto heaven. But the policy of theſe ambitious builders being contrary to the charitable decree of God, to have the earth peopled, he made uſe of that very conſpiracy, that brought them together, to effect that, which they conſpired to prevent; ſo that now the remoteſt parts of the inhabited world are but the colonies of *Babel*, whoſe ſcattered architects have indeed made themſelves a name, but upon a quite contrary account than they intended or expected. Thus the purblind envy of *Joſeph's* brethren, having made them reſolve to prevent his future dreams of ſuperiority over them, made them think, that, by ſelling him for a ſlave, they had taken ſufficient order he ſhould never come to be their maſter. And yet we ſee, that *Joſeph's* being ſold into *Egypt* was made uſe of by the wiſe orderer of human affairs, to make him in effect Lord of that rich and populous kingdom, and thereby, of his envious brethren, *Pharaoh's* dreams having advantageouſly made him amends for the hardſhips his own had expoſed him to. So the proud favourite of *Ahaſuerus*, queſtionleſs, thought he could ſcarce miſs his ends, when, by the counſel of his friends, and, as he fondly thought, of his gods too, he provided for *Mordecai* that fatal gibbet, which probably he might have eſcaped, if he had not erected it. Thus the high prieſt, and the ſanhedrim of the Jews, ſeemed to act with much policy, though no juſtice, when they reſolved upon the death of our Saviour; leſt, as the Goſpel tells us, the Romans ſhould come and deſtroy their temple, and nation; which, whether indeed it did not rather procure, than divert the coming of the Romans, the church-hiſtory can inform you. Nay, the old ſerpent himſelf, that arch-politician, that was the inſtructor of thoſe others I have been naming, even in his chiefeſt maſter-piece, found himſelf the moſt over-matched by him, to whom the Scripture aſcribes the taking of the wiſe in their own craftineſs. For, queſtionleſs, he highly applauded his own ſubtilty, and ſeemed to have taken the directeſt, and moſt proſperous way to his impious ends, that could be deviſed; when, having made *Herod* and *Pilate* friends, upon ſuch terms, that the Lamb of God ſhould be the victim of their new confederacy, he had engaged both Jews and Gentiles in a ruinous and tragick conſpiracy, to kill the prince of life, and, by that unparallelled crime, at once deſtroy the devil's chief enemy, and make God their's. And yet the event has ſufficiently manifeſted, that the Apoſtle might well affirm, that Chriſt, by his death, deſtroyed him, that had the empire of death, the devil; and that Satan's kingdom never received ſo deadly a wound, as that which pierced our crucified Saviour's ſide. Wherefore, in ſhort, (concludes *Euſebius*) the decrees of providence are too ſolid and fixed, to have violence offered them by human attempts, how ſpecious ſoever they be; and thoſe, that think to bring God to their bent, will find, at long running, that they have to do with one, whoſe power and wiſdom are ſo over-ruling, that not only he can fruſtrate their utmoſt endeavours, but make thoſe very endeavours fruſtrate themſelves, and employ men's ſubtileſt policies, to accompliſh thoſe very things they were deſigned to defeat.

Gen. xi. 6.

DISCOURSE XIV.

Upon catching ſtore of fiſh, at a baited place.

AS ſoon as we were come to the place the fiſherman told us of, we found it as plentifully ſtored with fiſh, as he had foretold us; and caught more in ſome few minutes, than we had taken in a whole hour before: but we did not half ſo much marvel at this, as we were pleaſed with it, becauſe the fiſherman informed us, that he had liberally baited the place over-night with corn, as well as worms. Whilſt this pleaſant exerciſe laſted, *Euſebius*, marking how great a reſort of fiſhes there was in that place, and how faſt we drew them up, upon comparing what he ſaw happen with the occaſion of it, thus acquainted

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us with the thoughts thereby ſuggeſted to him. Thoſe (ſays he) that yeſterday in the evening might ſee this man (pointing at the fiſherman) throw in his baits by handfuls into this place, and then depart, as minding them no more, were probably, if they knew not his deſign, and the cuſtom of fiſhers, tempted to think him a waſteful prodigal, or, at beſt, a venturous fool, to bury his corn in the river, and throw his baits to be caught up by fiſhes, that, for aught he knew, would never come back to thank their hoſt. But thoſe, that know (what we now find) how profitable a courſe this is wont to prove, would, inſtead of thinking ſuch a practice a piece of folly, look upon it as a piece of providence: for though he be ſure not to recover, in kind, the things he caſt upon the waters, yet ſuch a loſs is wont to prove very gainful unto him, whilſt he loſes but a grain of corn, or a worm, to obtain fiſhes of far more value. Thus, though the purblind world may think a liberal alms-giver, or a generous confeſſor, a fool, or a prodigal, whilſt they only conſider him as one, that throws away what he has in preſent poſſeſſion, and ſeems not ſo much as to hope for the recovery of the ſame goods, or any of the like nature; yet thoſe, whoſe eyes being illuminated with a heavenly light, are thereby enabled to look into the vaſt and diſtant regions of the future, and to deſcry there the final iſſues of all temporal things, will be ſo far from thinking him unwiſe, for parting with unſatisfying trifles, to procure the higheſt and moſt permanent goods, that they will think his proceedings far more juſtifiable, in point of prudence, than we now think the fiſherman's: nor will the parting with a greater fortune, as freely as with a leſſer, any more alter the caſe, than the fiſherman's throwing in his bigger worms, and grains of corn, with no more ſcruple than his leſſer. For heaven does as well incomparably out-value the greateſt, as the leaſt goods, poor mortals can lay out for it; and he, who has all things to give, and is infinitely more than all himſelf, has promiſed, that thoſe that ſow plentifully, ſhall reap ſo too; and though the leaſt of future acquiſts would incomparably tranſcend the greateſt price, that can be here given for it, yet the future rewards will, betwixt one another, bear a proportion to the occaſions of them. And, as the fiſherman is ſure to loſe what he throws into the water, and is not ſure to get by it any thing of greater value than ſome fiſhes, the Chriſtian adventurer (if I may ſo call him) may hope, though not confidently promiſe himſelf, in this world, the hundred-fold mentioned by our Saviour, as well as in the world to come life everlaſting. And therefore, if we do indeed, in St. *Paul*'s language, look, not to the things, which are ſeen, which are but temporary, but to the inviſible ones, which are eternal, we ſhall think that exhortation of his very rational, as well as very pious, where, having diſcourſed of the future and glorious ſtate of the true Chriſtians, he concludes, *Wherefore, my beloved brethren, be ye ſtedfaſt, immoveable, always abounding in the work of the Lord; for as much as you know, that your labour is not in vain in the Lord.*

DISCOURSE XV.

Upon the magnetical needle of a ſun-dial.

WE had not yet diſmiſſed the waterman, when *Eugenius*, chancing to expreſs a curioſity, to know what o' clock it was, when we had freſhly begun to angle at our new ſtation; as *Lindamor* and the reſt drew their watches to ſatisfy his queſtion, ſo the boat-man took out of his pocket a little ſun-dial, furniſhed with an excited needle, to direct how to ſet it, ſuch dials being uſed among mariners, not only to ſhew them the hour of the day, but to inform them from what quarter the wind blows. Upon the ſight of this dial, my natural curioſity invited me, after it had told me the hour, to try, whether the magnetick needle were well touched, by drawing a little penknife out of a pair of tweezes I then chanced to have about me, and approaching it to the north point of the needle, which, according to the known cuſtom of ſuch needles, readily followed it, or reſted over-againſt it, which way ſoever I turned the penknife, or whereabout ſoever I held it ſtill. *Euſebius* ſeeing me give my ſelf this diverſion, came up to me to be a ſharer in my ſight, which no familiarity can keep from being a wonder: but, after a while, he looked upon it in a way, that made me think it preſented him ſomewhat elſe than the hour of the day, or the corner of the wind; and I was confirmed in that thought, by ſeeing him apply to it the caſe of *Lindamor*'s watch, and then a diamond-ring, plucked from his own finger, and, in effect, he ſoon began to tell me; Methinks, *Philaretus*, this needle may afford us a good direction in the choice of companies; and that is a matter of ſuch moment, that ſome divines perhaps would queſtion, whether or no the direction it gives navigators, to find the poles, be of much greater importance. For not only it has been truly obſerved, that the choice of one's company does exceedingly diſcover, whether a man be good or bad, wiſe or fooliſh; but I ſhall venture to add, that it does very much contribute to make him what others ſay it declares him: for an aſſiduous converſe does inſenſibly diſpoſe, and faſhion our minds and manners, to a reſemblance with thoſe we delight to converſe with; and there are few, that have ſo much reſolution, as to diſobey cuſtoms, and faſhions, eſpecially when embraced by perſons, that we love, and would be eſteemed by, and from whoſe opinions, and practices, we can ſcarce diſſent conſtantly, without impreſſing a diſlike, that threatens to make them diſlike us. For my part, (ſays *Lindamor*) I have always thought, there is great difference betwixt keeping company with ſome men, and chuſing to do ſo; for, whilſt we live in this world, we muſt often have to do with the lovers of the world: but though to be caſt, by the exigencies of our callings, upon bad company, be an infelicity without being a fault, yet certainly, to chuſe ſuch company,

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and prefer it before that of wiſe and good men, is, in a high degree, both the one and the other. And I confeſs, (continues he) I cannot think, that the proper uſe of converſation is but to paſs away our time, not to improve it.

YOU are certainly much in the right (ſubjoins *Euſebius*;) for though too many of thoſe, that are now cried up for good company, do either ſo diſſuade us from good and ſerious things, or ſo divert us from them, that it is oftentimes counted a piece of indiſcretion, to ſay any thing, that may either enrich men's underſtandings, or awaken their conſciences; yet I cannot but think, that converſation may be, as well as ought to be, reſcued from being an inſtrument to promote idleneſs and vice; and, if men were not wanting to themſelves, I doubt not, it may be ſo ordered, that converſation, which ſo often robs men of their time, and ſo frequently of their devotion, might be made a great inſtrument of piety, and knowledge, and become no leſs uſeful, than it is wont to be pleaſant.

TO make companies (replies *Lindamor*) ſuch as you think they may be, they muſt grow very different from what moſt commonly they are: for, not to ſpeak of thoſe looſe and profane ones, where virtue and ſerioufneſs are openly derided; and any thing, how contrary ſoever to piety, or right reaſon, may be uſed, not only with toleration, but applauſe, if men can bring it out, I ſay not in jeſt, (for they are ſeldom more in earneſt) but neatly wrapt up in raillery; even in thoſe civiller ſorts of company, where vice is not profeſſedly maintained, you ſhall ſeldom, during a long ſtay, hear any thing, that is really worth carrying away with you, or remembering when you are gone. And, to diſcourſe of any thing, that is grave enough, either to exerciſe men's intellects, or excite their devotion, is counted a piece of indiſcretion, that is wont to be more carefully avoided, than almoſt any thing that is really ſuch; ſo that, even in ſuch companies, the innocenteſt uſe, that we are wont to make of our time, is to loſe it. And really (continues *Lindamor*) when I conſider, how enſnaring the worſer ſort of companies are, and how little even thoſe, that do not openly defy piety and knowledge, are wont to cheriſh either of them; I begin to be reconciled to hermites, who fly from ſuch converſations, as are ſo apt to make men either vicious, or at leaſt idle, into thoſe ſolitudes, where they are not like to be tempted, either to renounce their devotion, or to ſuppreſs it, to entertain idle thoughts, or ſtifle good ones. Nor could I, without much ſcruple, as well as impatience, allow my ſelf to ſpend ſome part of my time in ſuch kind of entertainments, as many ſpend moſt of their's in, were it not, that looking upon civility as a virtue, and hoſpitality, as in ſome caſes a duty, and upon both of them as things of good report, I can think thoſe hours, they make me ſpend, may be juſtly caſt upon their account, and that the ceremonious and inſignificant converſations, whereto they oblige me, may be undergone upon ſome ſuch account, as that, on which ſerious parents converſe, and often-times play with their children. For as, though the things they do, are in themſelves trivial, and uſeleſs, yet they may be juſtifiable effects of a paternal care to ſtill a child, or keep him from harming himſelf; ſo the duty of exerciſing of civility makes me look upon as juſtifiable, though unpleaſant, thoſe expreſſions of it, which, in themſelves conſidered, I could not reflect on without indignation, and could not but think very much below any man, whom education has fitted for the exerciſe of reaſon, or whom religion has elevated to the hopes of heaven.

BUT it may (ſays *Euſebius*) on the other ſide be repreſented, that ſince it is ſcarce poſſible not to meet ſometimes with companies, that are not of the beſt ſort, we ſhould look upon thoſe neceſſities, as calls of providence, to improve thoſe opportunities for the advantage of them we are ingaged to converſe with: for nature, as well as Chriſtianity, teaches us, that we are not born only for ourſelves, and therefore, as we ought often to converſe with the beſt men, to acquire virtue and knowledge; ſo we muſt ſometimes converſe with others, that we may impart them, and learn how much we are beholden to God's goodneſs, that has ſo much diſcriminated us from other men. And though we do not find, that our converſation does immediately and viſibly reform thoſe we converſe with, yet it will not preſently follow, that it is altogether ineffectual on them: for, beſides that the ſeeds of virtue and knowledge, as well as thoſe of plants, may long ſeem to lie dead, even in thoſe ſoils, wherein they will afterwards flouriſh and fructify, there may be at preſent a good, though not a conſpicuous, effect of your diſcourſe and example. For when men are haſting to hell, he does them no ſmall ſervice, that does ſo much as retard their courſe; as cordials, and other medicines, may do good even to decrepid old men, whom they cannot perfectly cure.

AND truſt me, *Lindamor*, it is no ſuch uſeleſs performance as you may think it, for a man of known piety and parts, by converſing with the children of this generation, to dare to own religion among thoſe that dare to deride it; to keep alive and excite a witneſs for God and good things in their conſciences; to let them ſee, and make them (at leaſt inwardly) acknowledge, the beauty of a pious, induſtrious, and well-ordered courſe of life; to convince them, that it is not for want of knowing the vanities they doat on, that he deſpiſes them; to ſhew, that a man that denies himſelf their ſinful jollities, can live contented without them: and, (to diſpatch) to manifeſt, by a real and viſible demonſtration, that a virtuous and diſcreet life is no unpracticable, no more than melancholy thing, even in bad times, and among bad men. And, ſays *Euſebius*, to me it ſeems very conſiderable, that our Saviour himſelf, the great author of our faith, and exemplar of our piety, did not chuſe an anchorite's, or a monaſtick life, but a ſociable and an affable way of converſing with mortals, not refuſing invitations, even from publicans, or to weddings, and by ſuch winning condeſcenſions gained the hearts, and thereby a power to re-

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form the lives, of multitudes of thoſe he vouchſafed to converſe with.

OTHER conſiderations (purſues *Euſebius*) might be repreſented to the ſame purpoſe with theſe: but ſince I promiſed you ſomething of direction, I ſuppoſe you will expect I ſhould tell you not what I *could* ſay, but what I *do* think. I will tell you then in few words, that though I think it as well poſſible as fit for men of radicated virtue, and fine parts, to make ſometimes a good uſe of bad company, eſpecially when their lawful occaſions caſt them into it; yet, for others to be often ingaged in ſuch company, though it may be but an infelicity, is a very great one; and to chuſe ſuch company, is, what is worſe than an unhappineſs, a fault. But generally ſpeaking, I would diſtinguiſh three ſorts of companies: for there are ſome, that not only are unable to improve me, but are unwilling to be improved themſelves. A ſecond ſort there is, that are as well ready to learn, as able to inſtruct: and there are others, that, though they are not proficients enough to teach me things worth my learning, are yet deſirous to be taught by me the little, that I know, and they ignore. Now, as the magnetick needle we were looking on, and which affords us the theme of this diſcourſe, if you ſhould apply a load-ſtone to it, would be moſt powerfully attracted by that, becauſe it can receive freſh virtue from it; and even, if you approach a piece of ſteel to it, the needle will, though not ſo ſtudiouſly, apply itſelf to it, from which, though it receives no magnetick virtue, it can impart ſome to it; but if you offer it the ſilver caſe of your watch, or the gold, that makes up your ring, or the diamonds, that are ſet in it, none of all theſe, how rich or glittering ſoever, will at all move the needle, which ſuffers them to ſtand by it unregarded: ſo I ſhall, with the moſt of cheerfulneſs, and application, ſeek the company of thoſe, that are qualified to impart to me the virtue or the knowledge they abound with. Nor ſhall I refuſe to entertain a ſociety with thoſe few, that being ſuch ſmall proficients as to need to learn of me, are alſo forward to do ſo. But thoſe, that can neither teach me any thing, that is good, nor are diſpoſed to let me teach them, how great a ſhew ſoever they make among thoſe, that make choice of their companions by their eyes; I may be caſt upon their converſation, but ſhall very hardly chuſe it.

DISCOURSE XVI.

Upon the quenching of quick-ſilver.

I HAD almoſt forgot to relate, that not far from the place, where we went on ſhore, and which we had not yet quitted, we ſaw divers heaps of quick-lime, ſome ſmoking, and ſome, that had not yet been drenched in water; and upon inquiry of thoſe, that looked to it, we were ſoon informed, that the conveniency of the neighbouring river, both for ſlacking of lime, and conveying mortar, had made the owners bring their lime thither, to be tempered and made fit for the reparation of ſome houſes, that we ſaw a little way off: but while we were talking, one of the workmen began to throw water upon one of the heaps, that had not yet been ſlacked, and afterwards poured on ſo much more as ſerved quite to drown the lime; and *Euſebius* marking, both what he did, and what enſued upon it, took thence occaſion to ſay to us; he, that ſhould ſee only the effect of the firſt effuſion of cold water upon quick-lime, would think, that by a kind of antiperiſtaſis, the internal heat of the lime is rather increaſed than ſuffocated by the coldneſs and moiſture of the water: for that, which before was not taken notice of, to manifeſt any ſenſible warmth, as ſoon as its enemy, the water, begins to invade it, acquires a new heat and new forces in the conflict, and not only ſhews a great impatience, or enmity, to that cold liquor, by acting furiouſly upon it, and throwing off many parts into the air, but prevails ſo far as to heat that cold element itſelf, to that degree, as to make it ſmoke and boil. But this conflict is ſeldom near ſo laſting as it is eager; for if you have but the patience to ſtay a while, you ſhall ſee the lime, after it has ſpent its occaſional ardour, and after its fire is quenched, lay quietly with, nay under, the water, as cold and as moveleſs as it. Thus, when a devout man, (eſpecially if his fervour be adventitious from education, or cuſtom, as the fire in the lime from the calcination) firſt falls into the company of perſons, either profane, or otherwiſe groſsly vicious, we often ſee, that his zeal, inſtead of being ſmothered by ſuch a rude and unaccuſtomed oppoſition, ſeems rather to be excited and kindled thereby, and poſſibly ſeems more likely to impart the warmth of his devotion to its enemies, than to loſe any of it himſelf; but when he is conſtantly, or at leaſt frequently, ſurrounded with ſuch company, you will too often ſee him loſe as well his own ardour as the endeavours of communicating it; and with thoſe very perſons, that did at firſt kindle and exaſperate his zeal, you ſhall at laſt ſee him live very quietly, and perhaps manifeſt as little of religious warmth as they; and that, which at firſt did ſo ſtrangely exaſperate and diſcompoſe him, becomes after a while ſo familiar, as not at all to move him.

DISCOURSE XVII.

Upon one's talking to an echo.

WE had poſſibly dwelt longer upon ſuch reflections, had I not been ſuddenly diverted by the repeated clamours of a voice, which each of us imagined he had very often heard: whereupon, as it were by common conſent, we began to look round about us, to ſee if any of our little company were miſſing; and finding that *Eugenius* was ſo, we readily concluded the voice we heard, though ſomewhat altered by diſtance, and other circumſtances, to be his; and accordingly we haſted towards the place, whence we judged the voice to proceed, that in caſe he were in any diſtreſs, or had met with any diſaſter, we might reſcue or relieve him: but when we came near, we could now and then diſtinctly hear him ſpeak

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ſome words ſo loud, and yet ſo incoherent and unable to complete a ſenſe, as if he meant, that all thereabouts ſhould hear him, and no body underſtand him. This made us double our curioſity, and our pace, till at length we deſcried him all alone in a ſolitary corner, wherein yet his loudneſs kept us from believing he ſought privacy: but as ſoon as he diſcovered us, he ſeemed both ſurprized and troubled at it. Coming to meet us, he firſt begged our pardon, if having been louder than he thought, he had put us to a trouble he did not intend; and then laughing, aſked us, if we did not think him mad: but *Euſebius* ſmiling told him, that before we could anſwer that queſtion, we muſt aſk one of him, which was, what he had been doing? Whilſt you, (anſwers *Eugenius*) were (I doubt not) better employed, my natural curioſity ſeduced me to ſpend ſome time in ranging about the places near the river-ſide; and as I was paſſing by this field, the accidental lowing of an ox made me take notice, that this neighbouring hill and wood furniſh this place with an excellent echo, which I at firſt tried only by whooping and hollowing; but afterwards diverted my ſelf by framing my queſtions ſo, as to make that babling nymph (for ſo you know the poets will have echo to be) to diſcourſe with me.

FOR my part, (ſays *Lindamor*) I ſhould by no means like her converſation, becauſe that two qualities ſhe has, which to me would very much diſcommend it: and to prevent our aſking him what thoſe qualities were, one of them, (ſays he) is, that ſhe vouchſafes to diſcourſe indiſcriminally with all comers that talk to her, provided that they make noiſe enough.

YOU are much in the right, (ſays *Eugenius*) for that eaſineſs of admitting all kind of company, provided men have boldneſs enough to intrude into ours, is one of the uneaſieſt hardſhips, (not to ſay martyrdoms) to which cuſtom has expoſed us, and does really do more miſchief, than moſt men take notice off; ſince it does not only keep impertinent fools in countenance, but encourages them to be very troubleſome to wiſe men. The world is peſtered with a certain ſort of praters, who make up in loudneſs what their diſcourſes want in ſenſe; and becauſe men are ſo eaſy-natured, as to allow the hearing to their impertinencies, they preſently preſume, that the things they ſpeak are none; and moſt men are ſo little able to diſcern in diſcourſe betwixt confidence and wit, that like our echo, to any that will but talk loud enough they will be ſure to afford anſwers. And, (which is worſe) this readineſs to hazard our patience, and certainly loſe our time, and thereby incourage others to multiply idle words, of which the Scripture ſeems to ſpeak threateningly, is made by cuſtom an expreſſion, if not a duty, of civility; and ſo even a virtue is made acceſſary to a fault.

FOR my part, (ſubjoins *Eugenius*) though I think theſe talkative people worſe publick grievances than many of thoſe, for whoſe prevention, or redreſs, parliaments are wont to be aſſembled, and laws to be enacted; and though I think their robbing us of our time as much a worſe miſchief than thoſe petty thefts, for which judges condemn men, as a little money is a leſs valuable good, than that precious time, which no ſum of it can either purchaſe or redeem; yet I confeſs, I think, that thoſe of our great lords and ladies, that can admit this ſort of company, deſerve it: for if ſuch perſons have but minds in any meaſure ſuited to their qualities, they may ſafely, by their diſcountenance, baniſh ſuch pitiful creatures, and ſecure their quiet, not only without injuring the reputation of their civility, but by advancing that of their judgment. And I fear, (continues *Eugenius*) that thoſe, who decline this imployment (and indeed improvement) of their titles, or other kinds of eminency, do, by their remiſſneſs, more harm than they imagine; for though the judgment and company of ſuch perſons be not always the beſt grounded, or the beſt choſen, yet their quality or ſtation in the world makes it uſually the moſt conſpicuous, and the moſt conſidered. And I doubt not, there is no ſuch multitude of diſintereſted lovers of good things, but that there will be the fewer found ſtudious to expreſs wit and virtue in converſation, when they ſee, that in the eſtimate of thoſe, that are looked upon as the chief judges of what is or is not good company, the moſt empty and impertinent prattle with confidence, or loudneſs, procures a man at leaſt as good a reception, as the beſt and moſt rational diſcourſe without it. And, which is yet worſe, that tyrannous thing, which we miſ-name civility, has ſo degraded reaſon, as well as diſplaced piety, in converſation, that if there be never ſo many perſons together, entertaining themſelves with rational or inſtructive diſcourſe, in caſe there come in but one impertinent creature, that is below it, all theſe ſhall ſink themſelves to his level, and as much debaſe their diſcourſe, as if they believed it fitter, that all the rational converſers ſhould forego the exerciſe and the benefit of their wit and virtue, than that a fool ſhould not appear to talk as wiſely as any of them. And thus they ſeem aſhamed of their attainments, inſtead of making him aſhamed of his ignorance, and reducing him to improve himſelf into a capacity of being fit for their company; whereas, from a contrary practice, they might derive the great advantage, either of freeing themſelves from uninvited companions, or of making them worth the having.

BUT, (ſubjoins *Lindamor*) I remember I told you there was a ſecond quality, that I diſliked in the nymph I found you entertaining, and that is, that, when I will, I can make her ſpeak to me, juſt what I pleaſe. I know (replies *Eugenius*) that a moderate degree of complaiſance is not only in many caſes allowed us by diſcretion, but neceſſary to keep up the pleaſantneſs, not to ſay the very peace, of human ſocieties; for if all men, at all times, ſpeak their minds freely, and did not ſoften one another by concealing their mutual diſlikes, and diſſents, and by certain outward expreſſions of kindneſs, or reſpect, made by compliments and geſtures, men have ſo many imperfections, and ſo much ſelf-love withal, that ſcarce any

two of them would endure one another; nay, and in ſpite of that indulgence, which provident nature has implanted in all animals, for the preſervation of their ſpecies, in that of the individuals that compoſe it, and as much as our own faultineſs has added to that fondneſs; yet, I doubt, we ſhall ſcarce find one man of a thouſand, that would endure ſo much as himſelf, if we did not for the moſt part exerciſe complaiſance within our own breaſts, and did not as much flatter our ſelves, and diſguiſe our ſelves, to our ſelves, as we flatteringly diſguiſe our ſelves to others.

BUT, (continues *Eugenius*) when all this is ſaid, I may endure, but I ſhall ſcarce chuſe and prize a companion, that, like an echo, uſes no liberty of his own, but allows me to direct whatever I would have to be anſwered me: and I know not whether I could not better like one, that would ever diſſent from me, than one that would never do ſo. I cannot look upon him either as my friend, or as a perſon worthy to be made ſo, who never evinces his being more concerned to advantage me, than to pleaſe me, by making uſe of the liberty of a friend, and thereby ſhewing, that he conſiders not barely himſelf, but me: beſides, that as there is no true friendſhip, where there is not an union of affections, ſo methinks there can be no good company, where there is not ſometimes a diſſent in opinions.

EUSEBIUS, that was a friend to ſerioufneſs, without being an enemy to pleaſantneſs, gathering from the long pauſe made by his friends, that they deſigned not the proſecuting of this diſcourſe any further; Methinks, gentlemen, (ſays he, ſmiling) you are very ſevere to a harmleſs nymph, who is ſo modeſt, and reſerved, that ſhe will never put you upon beginning a conference with her, and ſo complaiſant in it, that it is your own fault, if ever ſhe ſays any thing to you, that diſpleaſes you: and for my part, (continues he) I have that opinion of human things, that as I think there are very few ſo perfect, but that we may find ſomething in them fit to be ſhunned, ſo there are not many ſo imperfect, but that they may ſuggeſt to us ſomewhat or other, that may not be unworthy of our imitation; and as *Lindamor* has taken notice of two qualities in our echo, which diſcommended it to him, ſo I have obſerved as many, that I rather approve than diſlike.

FOR, in the firſt place, it is evident, that our nymph (however *Eugenius* has been pleaſed to miſ-call her a babler) is much leſs talkative than moſt of her own ſex, or indeed of ours; for ſhe never begins to talk with any body, not ſpeaking unleſs ſhe be ſpoken to. He that conſiders how much of the diſcourſe, that waſtes men's time, and entertains the moſt companies with the moſt applauſe, conſiſts of talk, that tends either to flatter thoſe that are preſent, or detract from the abſent, or to cenſure our ſuperiours, or our betters, or to expreſs our own profaneneſs, or to excite the pride or carnality of others; and he that ſhall conſider, that though by theſe and many other ways we are extremely apt to offend in words, yet we muſt give an account for that kind of words, what ſort ſoever be meant by them, which our tranſlators render idle ones; and that the judge himſelf tells men, that they ſhall by their words, as well as by their actions, be juſtified, or condemned; will eaſily believe, that if ſilence were as much in faſhion, as it is charitable to mankind to wiſh it, the regions of hell would be far thinlier peopled than now they are like to be.

I COULD tell you, that ſilence diſcovers wiſdom, aad conceals ignorance; and it is a property, that is ſo much belonging to wiſe men, that even a fool, when he holdeth his peace, may paſs for one of that ſort; and I could eaſily add I know not how much in the commendation of this excellent quality, if I knew how at the ſame time to praiſe ſilence, and to practiſe it: ſo that it may well paſs for an excellency in the nymph, whoſe apology I am making, that ſhe does not ſpeak, but when it is neceſſary ſhe ſhould, I mean, when ſhe is ſpoken to, in ſuch a way as does exact her anſwer.

BUT this is not all the good qualities of our echo; for as ſhe rarely ſpeaks, but when it is expected ſhe ſhould, ſo ſhe ſeldom repeats above a ſmall part of what is ſaid to her: this I account a very ſeaſonable piece of diſcretion, eſpecially in ſuch treacherous and fickle times as ours, where, almoſt as if he thought himſelf fit to be an univerſal ſtateſman, ſuch a one concerns himſelf very needleſly for almoſt all the publick quarrels in Chriſtendom, and ſhews himſelf zealous for a party, which will receive no advantage by his diſquiets; and not content like a merchant-venturer, his paſſion may upon this account make him a ſufferer by what happens in the remoteſt parts of the world. In our own fatal differences, (which it is almoſt as unſafe to ſpeak freely of, as it is unhappy to be involved in them) he will on needleſs occaſions declare, with his opinion, his want of judgment, and perhaps ruin himſelf with thoſe, under whoſe protection he lives, by ſpreading reports, and maintaining diſcourſes, that rendered him ſuſpected among thoſe, who think, that a man muſt wiſh their forces ſhould be beaten, if he can think they may have been ſo: nay, I have known ſome, that, though put into conſiderable employments, could not hold talking of their own party, at a rate of freedom, which thoſe that have ſo much innocence as not to deſerve it, will ſcarce have ſo much goodneſs as to ſupport it. So that methinks, theſe men deal with their fortunes as children oftentimes do with their cards, when having taken a great deal of pains to build fine caſtles with them, they themſelves afterwards ruin them with their breath.

IT may be a greater, without being a more prejudicial piece of folly, to believe all that one hears, than to report all that one believes; and eſpecially, thoſe are to be cenſured for want of our nymph's reſervedneſs, by whom it loſes that name: for though thoſe kind of men make ſure, by their way of talking, to make others take notice, how much they are confided in by their own party, yet ſure they would take a

diſcreeter

diſcreeter diſcourſe, if they did but conſider, that the proof they give, that they are truſted with ſecrets, is, that they are unfit to be ſo.

DISCOURSE XVIII.

Upon a giddineſs occaſioned by looking attentively on a rapid ſtream.

THESE thoughts of *Euſebius* ſuggeſted ſo many to *Lindamor*, and me, that to entertain our ſelves with them, we walked ſilently a good way along the river ſide; but at length, not hearing any more the noiſe his feet were wont to make in going, turning my ſelf to ſee what was become of him, I perceived him to be a pretty way behind me upon the river's brink, where he ſtood in a fixt poſture, as if he were very intent upon what he was doing. And it was well for him, that my curioſity prompted me to ſee what it was that made him ſo attentive; for, before I could quite come up to him, methought I ſaw him begin to ſtagger, and though that ſight added wings to my feet, yet I could ſcarce come time enough to lay hold on him, and, by pulling him down backwards, reſcue him from falling into the river. The ſhriek I gave at the ſight of my friend's danger, was, it ſeems, loud enough to reach *Euſebius*'s ears; who, turning his eyes towards the place whence the noiſe came, and ſeeing *Lindamor* upon the ground, made haſtily towards us, and came up to us by that time I had helped *Lindamor* up, and before I had received from him the obliging acknowledgments he was pleaſed to make for a piece of ſervice, that I thought had in it more of recompenſe than merit. *Euſebius* hearing what paſſed betwixt us, joined his thanks to *Lindamor*'s, and at the ſame time congratulated my friend for his eſcape, and me for having, to uſe his expreſſions, had the honour and ſatisfaction to be ſuch a perſon as *Lindamor*'s deliverer. But after our expreſſions of joy for his eſcape were over, *Euſebius* and I had both a curioſity to learn particularly the occaſion of his danger, which he told us in theſe words: As I was thinking, *Euſebius*, on your laſt reflection, I was diverted from proſecuting my walk in *Philaretus*'s company, by happening to caſt my eyes on a part of the river, where the ſtream runs far more ſwiftly, than I have all this day taken notice of it to do any where elſe, which induced me to ſtop a while, to obſerve it the more leiſurely: and coming nearer, I found the rapidneſs of the current to be ſuch, notwithſtanding the depth of the water, that I ſtood thinking with my ſelf, how hard it were for one to eſcape, that ſhould be ſo unlucky as to fall into it. But whilſt I was thus muſing, and attentively looking upon the water, to try whether I could diſcover the bottom, it happened to me, as it often does to thoſe that gaze too ſtedfaſtly on ſwift ſtreams, that my head began to grow giddy, and my legs to ſtagger towards the river; into which queſtionleſs I had fell, if *Philaretus* had not ſeaſonably and obligingly prevented it. Something like this (ſays *Euſebius*) does not unfrequently happen in the unwary conſideration of ſome ſorts of ſinful objects, eſpecially thoſe ſuggeſted by atheiſm and luſt: for not only we oftentimes conſider atheiſtical ſuggeſtions, and entertain libidinous fancies, without any intention to quit our ſtation, or the ſecure and ſolid baſis of religion and chaſtity; but we are often inclinable to think, that we converſe with theſe objects only to diſcern their formidableneſs the better, and fortify our reſolutions to ſhun them. And yet ſuch is the pernicious nature of atheiſm, and of luſt, that they turn our brains, and oftentimes, if providence, or Chriſtian prudence, do not ſeaſonably interpoſe, we may unawares fall into the miſchief, even by too attentively ſurveying its greatneſs, and may be ſwallowed up by the danger, even whilſt we were conſidering how great it is. To parley with ſuch faſcinating enemies, though with a deſign to refuſe them, and ſtrengthen our averſion to them, is againſt the laws of our Chriſtian warfare; and though it be not as criminal, may often prove as fatal, as to hold intelligence with the enemy. It is true, that the deformity of both theſe ſins is ſuch, that all their uglineſs cannot be taken notice of at firſt ſight; but the diſcovery is more dangerous than neceſſary, ſince a little knowledge of their hideouſneſs is enough to make every honeſt heart abhor them. And ſince their leſs obvious deformities are more dangerous to be pried into, than neceſſary to be known, let us fear to learn of theſe deluding ſins, more than we need know to hate them; and remember, that even thoſe, that are frighted by ſeeing faces recently marked with the ſmall pox, may, notwithſtanding that fear, catch the diſeaſe with that ſight.

DISCOURSE XIX.

Upon one's drinking water out of the brims of his hat.

WE were by this time come back to the baited places we had left, when *Eugenius*, to whom his rambling up and down, added to the heat of the day, had given a vehement thirſt, ſpying a place, where the banks were low, and almoſt level with the ſurface of the water, left us for a little while to repair thither; and kneeling upon the ground, he took up with his hat, which by cocking the brims he turned into a kind of cup, ſuch a proportion of water, that he quenched his thirſt with it; and careleſsly throwing the reſt upon the ground, quickly returned towards the company, which he found he had not left ſo ſilently, but that our eyes had been upon him all the while he was abſent: and that ſight afforded *Euſebius* an occaſion to tell us, our friend *Eugenius* might, if he had pleaſed, by ſtooping lower with his head, have drank immediately out of the entire river. But you ſee he thought it more ſafe, and more convenient, to drink out of a rude extemporary cup; and that this way ſufficed him fully to quench his thirſt, we may eaſily gather, by his pouring away of ſome remaining water as ſuperfluous: and if he ſhould tell us, that he could not have quenched his thirſt with a ſuf-

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ficient quantity of water, becauſe he drank it not out of the river, but out of his hat; I doubt not, you would think him troubled with a more formidable diſtemper than thirſt, and conclude him in a greater need of phyſick than of water.

THUS (reſumes *Euſebius*) to a ſober man, provided he have a competency of eſtate ſuited to his needs and conditions, it matters not very much, whether that competency be afforded him by a moderate or by an exuberant fortune, and oftentimes it is more ſafe and convenient, and no leſs ſatisfactory, to receive this competency out of that, which is but a little, than out of that, which is a great deal more than enough; for not only the neceſſities of nature are few, but her capacities are limited. And therefore, how much ſoever you have of meat, and drink, and the like accommodations; the body of a man can enjoy but a certain, and that too no very great meaſure of them, proportioned to the craving of our ſtinted nature, by more than which it is not the body, but the unruly fancy, that is gratified; as when the ſtomach is ſatisfied, a table full of untouched diſhes feeds but a man's eye, or his pride; and if he ſhould cram a little part of it into his ſtomach, it would be but nauſeated at firſt, and afterwards breed ill humours and diſeaſes. And accordingly, it is no leſs than *Solomon* that ſays, *when goods increaſe, they are increaſed that eat them; and what good is there to the owners thereof, ſaving the beholding of them with their eyes?* I dare not abſolutely (purſues he) condemn thoſe, that think not the neceſſities of nature the only meaſures of a competency of fortune; for though he, that wants not them, wants a juſt cauſe to quarrel with providence, yet cuſtom has ſo entailed ſome ways of expence upon ſome ſtations in the world, that ſince a man can ſcarce live without them, and yet without diſgrace, there are but few who are ſo great Stoicks, or ſuch mortified Chriſtians, as not to think, that what is more than enough for one, may be leſs than enough for another, and as to not eſtimate their having or wanting a competency, not only by the exigencies of nature, but by thoſe of a man's particular quality, or ſtation. But (ſubjoins *Euſebius*) he, that has, in this liberal ſenſe, a ſufficiency of outward goods, is, methinks, but ill adviſed, as well as unthankful, if he repine at his portion, becauſe it is inferiour to thoſe of the famouſly rich: For though an unwieldy affluence may afford ſome empty pleaſure to the imagination, (for to the body it ſcarce affords any at all) yet that ſmall pleaſure is far from being able to countervail the imbittering cares, that attend an overgrown fortune: for whatever the unexperienced may imagine, the frequent and ſad complaints of the rich themſelves ſufficiently manifeſt, that it is but an uneaſy condition, that makes our cares neceſſary for things, that are meerly ſuperfluous; and that men, whoſe poſſeſſions are ſo much ſpread and diſplayed, are but thereby expoſed the fairer and wider marks, that may be hit in many places by misfortune. Nor will careleſſneſs ſecure them, ſince a provident concern of a man's eſtate, though it be great, being by the generality of men looked upon as a duty, and a part of prudence, he cannot ſuffer himſelf to be wronged or cheated of that, without loſing, with his right, his reputation.

FOR my part, (ſays *Lindamor*) I do the more wonder to ſee men ſo greedy of lading themſelves, as the Scripture ſpeaks, with thick clay, that they hoard up their treaſures from thoſe uſes, which alone make riches worthy the name of goods, and live by a temper quite contrary to that of ſaint *Paul*, *As having all things, and poſſeſſing nothing*. When I conſider the things they pretend to by this as mean as unchriſtian appetite; the two chief of theſe are wont to be, the keeping of a great houſe, and the leaving their children great matches. As to the former, though others are too much advantaged by it not to extol it, and though it be ſometimes indeed in ſome caſes a decent, and almoſt neceſſary, piece of greatneſs; yet it is in my opinion one of the moſt unhappy attendants that retain to it; for the laws of hoſpitality, and much more thoſe of cuſtom, turns him, that keeps a great table, into an honourable hoſt, ſubjects him to comply with the various and oftentimes unreaſonable humours of a ſucceſſion of gueſts, that he cares not for at all, and that care as little for him; it brings him in a world of acquaintance, to whom he muſt own himſelf obliged, becauſe they come to eat his meat, and muſt really requite them by giving them the pretiouſeſt thing he has to part with, his time: and a full table, together with the liberties that cuſtom allows at it, if not exacts there, tempt him both to indulgence to his appetite, prejudicial to his health, and if they do not prevail with him to ſpeak, do often at leaſt to diſpoſe him to hear, and to connive at, ſuch free diſcourſes, as are prejudicial to his intereſts. So that there is more than one account, upon which a great entertainer may be involved in *David*'s curſe againſt his mortal enemy, of having his table become a ſnare.

AND for the deſign (continues *Lindamor*) of laying up vaſt eſtates for a man's children; if they be ſons, he thereby but increaſes their temptation to wiſh the father dead, and provides incentives to their vice, and fuel for their exceſſes, when he is ſo. And if they be daughters, not to repeat the newly-mentioned inconveniencies; how many unhappy young women have we ſeen, who, upon the ſcore of the vaſt portions left them by their parents, have been betrayed, and ſold by their guardians, or by thoſe relations, that ſhould have been, as they were called, their friends? And how often have we alſo ſeen, that an unwieldy fortune has been ſo far from purchaſing the heir to it a good huſband, that it has procured her a bad one, by making her think her ſelf obliged and qualified to match with ſome high title, and procuring her to be haunted by ſome, whoſe vices perhaps alone have reduced him

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him to ſell himſelf to redeem his fortune, and to make an addreſs which aims but at the portion, not the perſon? And accordingly, when he has got the one, he ſlights the other, and deſpiſes her for the want of that high extraction ſhe prized in him, and perchance hates her too, for confining him from ſome former and more than pretended paſſion.

I perceive then, *Lindamor*, (ſays *Euſebius*) that you are, as well as I, diſpoſed to think him not a meer fool, that prayed God to *give him neither poverty, nor riches, but to ſupply him with things ſuitable to his condition:* (that ſeeming to be the meaning of the Hebrew phraſe;) a pinching poverty, and a luxuriant fortune (though different extremes) being liable to almoſt equal inconveniences, and a competency affording us enough to engage us to thankfulneſs, without adminiſtering ſuch temptations to ſenſuality and pride.

Prov. xxx. 8.

DISCOURSE XX.

On ſeeing boys ſwim with bladders.

THE ſun was yet ſo near the meridian, that if the attention *Euſebius*'s diſcourſes excited, had not diverted us from minding the heat of the weather, we ſhould have found it troubleſome; and in effect, ſoon after we had left ſhining to the conferences I I have been repeating, we begun to feel a heat, uneaſy enough to oblige us to retire from it: but taking ſeveral ways, as chance or inclination directed us, to ſhun the ſame inconvenience, it was my fortune to hold the ſame courſe with *Lindamor*, and both of us, by following no guide, but the deſign of ſhunning all beaten paths, and unſheltered grounds, that being the likelieſt way to reach our double end of coolneſs and privacy; after we had a while walked ſomewhat near the river-ſide, we were at length brought to a ſhady place, which we ſhould have found, as well as we wiſhed it, a ſolitude, if others had not concurred with us in the ſame hopes: for the expectation of privacy had brought thither divers, whom the ſun's ſcorching heat invited to that cool and retired part of the river, where they hoped to ſhun all other eyes, as well as that of heaven; among thoſe ſwimmers we obſerved ſome novices, who to ſecure their firſt attempts, had bladders tied under their arms, to keep them from ſinking any lower. This ſight (ſays *Lindamor*, after he had a while muſed upon it) hath circumſtances in it, that, methinks, are applicable enough to the education of many of the young ladies of theſe times; of whoſe faults, the excellent *Celia*, and all the others, that you and I can think worth our concern, are free enough to let me entertain you without rudeneſs of them; the commonneſs of theſe blemiſhes ennobling thoſe few, that are exempted from them. You cannot then (continues *Lindamor*) but have obſerved with me, that many of thoſe young ladies, whoſe parents, out of a miſtaken zeal, condemn that, which at the court was wont to be called good breeding, and principles of honour, as things below a Chriſtian, and inſufficient to bring their poſſeſſors to heaven, are ſo unluckily bred, and ſo ill-humoured, as well as faſhioned, that an almoſt equally unhappy education is requiſite to make their company tolerable. Civility, which is almoſt as eſſential to a compleat lady, as her ſex, they are perfect ſtrangers to, or rude deſpiſers of it; and not only their minds are not imbued with thoſe principles of friendſhip, generoſity, and honour, which make ſome of their ſex ſo lovely, and ſo illuſtrious in ſtory, and of which more ladies would be capable, if more were taught them; but theſe are utterly uninſtructed in the laws of what the French call *Bienſeance*, and are altogether unpractiſed in that civility and ſuppleneſs of humour, which is requiſite to endear converſation, and is ſo proper to the ſofter ſex. I muſt confeſs, (purſues *Lindamor*) that I never have been more puzzled how to behave my ſelf than in their company: the ſerious ſort of diſcourſe, (even ſuch as is to be found in our freſher and more poliſhed romances) they are utterly incapable of; and in the trifling and pitiful prattle, that alone is not above them, they are ſo unſociable, ſo indiſcreet, and oftentimes ſo bold, that in ſpite of the reſpect, ſuch as *Celia* gives me for her ſex, I find in their converſations as much exerciſe for my patience as my chaſtity; and being tempted to put off the reſpect that belongs to ladies, as they do their modeſty, I find it more difficult to retain my civility than my liberty. The bladders (reſumes *Lindamor*,) which young ſwimmers uſe, are, it is confeſſed, but light and empty things, that are eaſily made uſeleſs; nay, though they help beginners, they are clogs to ſkilful ſwimmers; and yet theſe trifles are they, that hinder novices from ſinking into the mud. Thus honour, though it be an airy unſolid thing, nay, though it oftentimes proves a hinderance to great proficients in Chriſtianity, yet to perſons, that have not yet attained to higher principles, it is an excellent ſupport, and hinders them from ſinking into many meanneſſes and miſcarriages, into which thoſe eſpecially of the fairer ſex, that want a due ſenſe of honour, are too apt to be precipitated: you know what lord told his accuſed lady, that he knew ſhe was too proud to be a whore. And certainly, though principles of gallantry include not all virtues, yet they avert thoſe they ſway from groſſer vices: and though to be well bred be not to be a ſaint, but incomparably inferiour to it, yet to be both, is more deſirable than to be the latter only: and they are very unwiſe, who, before they are ſure their children will admit the higher and more perfect principles of religion, neglect to give them that education, that may render moral accompliſhments acceptable to them, and them to well bred company, leſt by proving indiſpoſed to ſpiritual graces, their not having been taught the moral ornaments of the mind leave them deſtitute of all good qualities.

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The TRANSITION.

Containing a DISCOURSE *upon the ſport's being interrupted by rainy weather.*

NOTWITHSTANDING the ſerenity and promiſingneſs of the morning we came out in, we have already upon the water had one proof of the unſettledneſs of the weather, and now upon the land we meet with another: for, by that time *Lindamor* was come ſomewhat near the end of this diſcourſe, he was obliged to haſten to it by the approach of a cloud, whoſe largeneſs and blackneſs threatned us with an imminent ſhower; nor did it give us a falſe alarm, for by that time we could recover the next ſhelter, the ſhower we fled from began to fall violently enough upon the trees, we were retired to. And this unwelcome accident reducing us all to look about us, we quickly ſaw, to our grief, that not only the rain but the clouds were increaſed, and the ſky being almoſt every where overcaſt, left us no way to eſcape the inconveniencies it threatned us with, but the making with what haſte we could towards the place, over which we perceived ſmoke enough, to conclude there was ſome village beneath it; and finding at our arrival thither as good an inn, as we could reaſonably expect in ſuch a place, after we had a while dried our ſelves by the fire, *Eugenius* (to whom exerciſe and the time of the day had given a good ſtomach) moved the company, that in ſpite of the meanneſs of the houſe, we might reſt our ſelves there, till we had dreſt the fiſh we had taken, to make up the beſt dinner the place would afford. This motion I did not alone readily aſſent to, but ſeconded it, by repreſenting, that probably by that time we had dined, we ſhould either recover ſome fair weather, or loſe the hopes of regaining it for that day. To which I added other conſiderations, to perſuade the company; though, that indeed, which prevailed with me, was, the expectation of having an opportunity, while dinner was providing, to retire, as I ſoon after did, into another room, and ſet down in ſhort hand what I have hitherto been relating, leſt either delay ſhould make the particulars vaniſh out of my memory, or they ſhould be confounded there by the acceſſion of ſuch new reflections, as, in caſe a fair afternoon ſhould invite us to return to the river, *Euſebius* would probably meet with occaſions of preſenting us. But before I could handſomely ſlink away, I happened to be entertained a while with ſome things of the like nature with thoſe I was about to ſet down: for this unwelcome change, after ſo glorious and hopeful a morning, did naturally ſuggeſt to all of us, ſome thoughts of the mutability and fickleneſs of proſperity, how eaſily, as well as quickly, we may be deprived of that we cannot eaſily part with. But whilſt the reſt of us were entertaining themſelves with theſe thoughts, *Eugenius*, who was more concerned than any other of us, for the ſport he came for, having a good while looked with melancholy eyes upon this change, began to repine and murmur at the interruption, which the perſiſting rain continued to give him in it. Whereupon *Lindamor* took occaſion to ſay, For my part, if I could diſſipate theſe clouds with a wiſh, I ſhould ſcruple at the ridding my ſelf of them, even at ſo eaſy a rate: for I ſee, that the gaping clefts of the parched ground do, as it were with ſo many mouths, proclaim its need of the rain you repine at. And I always (continues he) am ready to join with the huſbandman in his wiſhings, as well for rainy as for fair weather, and am ſo much a commonwealth's man, that I had rather at any time not eſcape a ſhower, than let him want it.

YOU are I confeſs, (ſays *Eugenius*) now I think a little better on it, in the right, and have more reaſon to be diſcontented at my impatience, than I at the weather: for we ſhould, even in theſe leſſer occaſions, as well as on greater, exerciſe ſelf-denial, and prefer a publick good to our private conveniences: and indeed it were far better, that I ſhould miſs ſome fiſhes, than thouſands of families ſhould miſs of bread.

EUSEBIUS, that had hitherto liſtened to what was ſaid, being unwilling, that his friend's ingenuity ſhould make him any longer accuſe himſelf, told him, (to divert the diſcourſe) This accident, *Eugenius*, was ſuggeſting to me a thought, wherewith I ſhall not ſcruple to acquaint you, and the company. For (continues he) as pleaſant, and as much deſired, as fair weather is wont to be, and as much as we uſe to be diſcontented at a lowering and dropping ſky, yet the one is no leſs neceſſary nor uſeful in its ſeaſon, than the other. For too uninterrupted a courſe of heat, and ſun-ſhine, would make the ſeaſon fruitful in nothing, but in caterpillars, (or ſuch kind of vermin) and in diſeaſes, and is far more proper to fill graves, than barns: whereas ſeaſonable viciſſitudes of clouds, and cloudy weather, make both the ground fruitful, and the ſeaſon healthful. Thus in our outward condition, too long and conſtant a proſperity is wont to make the ſoul barren of all, but ſuch wantonneſſes, as it is ill to be fruitful of, and the interpoſition of ſeaſonable afflictions is as neceſſary, and advantageous, as it can be unwelcome. But (purſues *Euſebius*) the conſideration, that chiefly entertained me, was this, that as here, to make the earth fruitful, the face of heaven muſt be now and then obſcured, and overcaſt, we muſt be deprived of the welcome pleaſure of the ſun to receive the fertilizing benefit of the rain; ſo ſuch is our condition here below, that our perverſeneſs makes it neceſſary, that God ſhould oftentimes appear to frown upon us, to make us fruitful in thoſe works, to which he is pleaſed to vouchſafe his ſmiles. But, oh! (concludes *Euſebius*, lifting up his eyes and hands towards heaven) how happy ſhall we be in that glorious and everlaſting day, when our condition ſhall be as bleſſed in not requiring viciſſitudes as in not being ſubject to them! When the ſun-ſhine alone ſhall perform all that is wont to be done here both by it, and by the rain; and the ſoul, like *Egypt*, being fruitful without the aſſiſtance of the clouds, we ſhall not need to have our joys eclipſed,

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eclipſed, to have our graces kept from being ſo, or to make our light ſhine the brighter: but each bleſſed ſoul ſhall be emblem'd by that viſion in the revelations, where St. *John ſaw an angel ſtanding in the ſun*; we ſhall not then need to have our love weaned from inferiour or undue objects, by any experience of their imperfections; ſince the clear diſcovery, that God will vouchſafe us of his own excellencies will abundantly ſuffice to confine our affections to them; and ſince the works, wherein we are to be fruitful in heaven, will be but to admire and thank him, that is infinite in beauty and in goodneſs, the perfecter ſight and fruition we ſhall have of his aſtoniſhing as well as raviſhing attributes, will but proportionably increaſe our wonder, and our praiſes, and will naturally make us as grateful for ſuch a ſtate as happy in it.

OCCASIONAL REFLECTIONS.

SECT. V.

REFLECTION I.

Upon the ſight of N. N. *making of ſyrup of violets.*

ONE, that did not know the medicinal virtues of violets, and were not acquainted with the charitable intentions of the ſkilful perſon, that is making a ſyrup of them, would think him a very great friend to Epicuriſm: for his employment ſeems wholly deſigned to gratify the ſenſes. The things he deals with are flowers and ſugar, and of them he is ſolicitous to make a compoſition, that may delight more than one or two ſenſes; for in one ſyrup he endeavours to pleaſe the eye, by the lovelineſs of the colour; the noſe, by the perfume of the ſcent; the taſte, by as much ſweetneſs as ſugar can impart. But he that knowing, that violets, though they pleaſe the palate, can purge the body, and notwithſtanding their good ſmell, can expel bad humours, knows alſo, that the preparer of theſe fragrant plants, in making their juice into a ſyrup, is careful to make it acceptable, that its pleaſantneſs might recommend it, and invite even thoſe to prove its virtues, who had rather continue ſick, than make trial of a diſguſting remedy; will not blame his curioſity, but commend his prudent charity; ſince he doubly obliges a patient, that not only preſents him remedies, but preſents him allurements to make uſe of them.

IF I ſee a perſon, that is learned and eloquent, as well as pious, buſied about giving his ſermons, or other devout compoſures, the ornaments and advantages, which learning or wit do naturally confer upon thoſe productions of the tongue, or pen, wherein they are plentifully and judiciouſly employed; I will not be forward to condemn him of a miſ-expence of his time or talents; whether they be laid out upon ſpeculative notions in theology, or upon critical inquiries into obſolete rites, or diſputable etymologies; or upon philoſophical diſquiſitions or experiments; or upon the florid embelliſhments of language; or (in ſhort) upon ſome ſuch other thing, as ſeems extrinſical to the doctrine, that is according to godlineſs, and ſeems not to have any direct tendency to the promoting of piety and the kindling of devotion. For I conſider, that as God hath made man ſubject to ſeveral wants, and hath both given him ſeveral allowable appetites, and endowed him with various faculties and abilities to gratify them; ſo a man's pen may be very warrantably and uſefully employed, though it be not directly ſo, to teach a theological truth, or incite the reader's zeal.

AND, beſides what I have been alledging, there is a further and more principal conſideration, which belongs to this matter. For even wiſe men may proſecute the ſame deſign, without doing it all of them the ſame way; and the ſeveral means and methods they employ, notwithſtanding a great difference in other particulars, may agree in this, that the reſpective chuſers of them had each of them a good aim, and proceeded in a rational way. Though therefore I ſee a man of good parts, ſtudious of learning, or of practiſing, the precepts of eloquence, and ſpend much time in reading florid compoſures, or in making ſuch; I dare not be forward to cenſure him for an effeminate or uſeleſs writer. For there are ſo many things pious or laudable, and ſo many ways, whereby ſome or other of them may either be directly promoted, or indirectly ſerved, by removing objections, or other impediments, that it is not eaſy to be ſure, that a rational man cannot have as well a rational as a well-meant deſign to inſtruct, if not reform, in thoſe very compoſures, that ſeem fitted only to delight. There being a nicer ſort of readers, which need inſtruction (and to whom it is therefore a charity to give it) who are ſo far from being likely to be prevailed on by diſcourſes not tricked up with flowers of rhetorick, that they would ſcarce be drawn ſo much as to caſt their eyes on them.

A WHILE before *Eſther* made that generous attempt, wherein, to reſcue the people of God, ſhe hazarded a throne, to which above an hundred other peoples paid homage, and ventured at once the greateſt crown and the faireſt head in the world; one, that had ſeen only what ſhe was doing, without knowing why ſhe did it, would perchance have thought her employed, more like a diſciple of *Epicurus* than of *Moſes*, whoſe people and her own was then in a forlorn and gaſping condition. For

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the Scripture telling us, that *ſhe put on her royal apparel*, and the tenour of the ſtory intimating with what aim ſhe did it, we may well ſuppoſe, that ſhe was not ſparing in jewels, and other of the richeſt ornaments, on an occaſion, where her quality exacted, that ſhe ſhould appear with a magnificence befitting the greateſt princeſs in the world; and that ſhe was very curious in a dreſs, that was to heighten her beauty, when by that, with the giver's aſſiſtance, ſhe was upon her knees, to dazzle the world's greateſt monarch on his throne, and make him pay homage to her charms, to whom above an hundred nations had preſented their faireſt productions, (the brighteſt nymphs of the Eaſt.) And thoſe, that have read any thing of the Aſiatick luxury, will eaſily believe our pious queen to have been alſo very ſollicitous about the choice and ordering of her ſweetmeats, when ſhe was to treat an Aſian monarch, who had treated the whole people of the chief city of the world for many days together, and as many princes, as made up the nobleſt part of mankind, for above twenty times as long: and yet this magnificent queen, that ſeemed buſied about none but ſenſual imployments, had ſo commendable a deſign both in her ornaments, and in her banquets, that ſo meritorious an imployment of her greatneſs ſhewed her to be worthy of it; and, as it appeared in the event, that her banquets did cooperate with her faſts, and her royal robes with *Mordecai*'s ſack-cloth and aſhes, to that happy reſcue of her nation, for which, after ſo many ages, it doth to this day yearly celebrate her memory: ſo whilſt ſhe ſeemed buſied to gratify others ſenſuality and her own pride, her diſpoſition of mind was ſo worthy the ſucceſs, that crowned her attempt, that at the ſame time ſhe was providing all that pomp and thoſe delicacies, ſhe was alſo providing to give them, and ſacrifice them, for the intereſt of God's church, and her people; generouſly venturing for the ſervice of heaven a height of proſperity, for whoſe loſs nothing but heaven itſelf could make her amends.

REFLECTION II.

Upon the ſight of a paper-kite in a windy day.

EUGENIUS, LINDAMOR.

EUG. IF the air were calm and quiet, this kite would lie unregarded even by thoſe very youths, that now look at nothing elſe. But the wind, that blows away ſtraws and feathers, and throws down leaves, does even by its being contrary, help to raiſe this paper-engine to that admired height, which makes it be gazed at by many others, than boys, and not only attract our eyes, but ſometimes ſoar out of their reach. Thus, if a great perſon, for courage, or parts, or both, have the ill fate to live in quiet, and peaceful times, he may long enough languiſh unregarded in an age that needs him not. But if the times grow troubleſome and dangerous, his generous ſpirit will not only ſurmount the difficulties, that are wont to attend them, but be raiſed by them, and turn them into ſteps to glory and preferment.

LIND. Methinks, *Eugenius*, theſe kites may affords us no leſs fit a reſemblance of the fate of ſome errors about religion, eſpecially if they chance to be maintained by men, that are reſolute, and viceleſs. For there are ſome of theſe conceits ſo fond, and groundleſs, that they could not long ſubſiſt of themſelves, and would ſoon ceaſe to tempt a ſolemn oppoſition, if they did not too ſoon meet with it. And as you were obſerving to another purpoſe, that theſe artificial kites, which men take no notice of in calm weather, are both elevated and kept aloft by the blaſts of contrary winds; ſo theſe erroneous opinions I ſpeak of, would, if they were let alone, grow quickly unregarded, whereas needleſs or ill-managed perſecutions of doctrine, not prejudicial to government, (for it is only ſuch, that I mean) bring them into every body's eye, and give them a repute, that nothing elſe would have procured them, and make them be looked upon as things of a ſublime and celeſtial nature, that lead to that heaven, they ſeem to aſpire to. To thrive by perſecution, though it be a great advantage, yet it is not the incommunicable prerogative of divine truths; and though it be certain that they get moſt by it, yet even errors do often gain by it too, there being certain advantages, that accrue to opinions, by being perſecuted, without diſtinguiſhing, whether they be true, or falſe. For men, that are perſecuted for their religion, are generally careful to inſtruct themſelves thoroughly in it, and furniſh themſelves with arguments to defend it. The frowns of the magiſtrate, and the watchful eyes of their adverſaries, are ſtrong diſſuaſives to them from doing any thing, that may arm his hand, or provoke other's tongues againſt their ſect, to which they know their perſonal faults will be imputed. And above all this, their ſufferings intitle them to popular commiſeration, which is a thing, that diſtreſs does ſo much invite, that even condemned malefactors ſeldom want a ſhare in it. And to ſome of theſe men perſecution is the more favourable, becauſe it puts them upon fighting with the weapons they can beſt handle. For ſome are far better at ſuffering, than at diſputing, and can more eaſily indure a priſon, than anſwer a ſyllogiſm. And as this conſtancy is often their beſt argument, ſo is it an argument, that the generality of men beſt underſtand, and conſequently is likely to be moſt wrought on by; ſo that the more harſh than effectual way, wherein they are dealt with, gives them the opportunity to diſplay a reſoluteneſs, that makes moſt men think them well meaning, and in earneſt, and their own party cry them up for martyrs, or at leaſt confeſſors; which, in caſe that (as it happens in moſt ſtates) ſcandalous ſins be left unpuniſhed at the ſame time, that harmleſs errors are ſo ſeverely dealt with, gives them the fairer opportunity to inſinuate into the minds of the people, that their perſecutors had rather ſee men vicious, than inquiſitive. And, generally ſpeaking, any perſonal ſufferings, that a well-meaning man undergoes for what he judges his conſcience,

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ſcience, is but ſuch a kind of burden to his mind, as feathers are to an eagle, or a falcon, which, though in themſelves conſidered they have a weight, yet inſtead of clogging him, they not only help him to ſupport himſelf, but enable him to ſoar towards heaven, and reach a heighth, that makes him praiſed or wondered at.

REFLECTION III.

Killing a crow (out of a window) in a hog's trough, and immediately tracing the enſuing reflection with a pen made of one of his quills.

LONG and patiently did I wait for this unlucky crow, wallowing in the ſluttiſh trough, (whoſe ſides kept him a great while out of the reach of my gun) and gorging himſelf with no leſs greedineſs, than the very ſwiniſh proprietaries of the feaſt, till at length having guzzled and croaked enough, when by hovering over his beloved dainties, he had raiſed himſelf high enough, to prompt me to fire at him, my no leſs unexpected, than fatal ſhot, in a moment ſtruck him down, and turning the ſcene of his delight into that of his pangs, made him abruptly alter his note, and change his triumphant chant for a diſmal and tragick noiſe. This method is not unuſual to divine juſtice towards brawny and incorrigible ſinners, whoſe ſouls no leſs black, than this inauſpicious bird's feathers, do wear already the livery of the prince of darkneſs, and with greedineſs do the works of it, whoſe delights are furniſhed (as the feaſts of crows are by carrion) by their own filthy luſts, or other people's faults, and who by the oaths and curſes, wherewith they offend Chriſtian ears whilſt they live, and by the ill odour they leave behind them when they are dead, do but too much juſtify my reſembling them to theſe hateful creatures. Such ſenſual and obdurate Epicures, I ſay, God oft times ſuffers to run on their long career, in paths of their own chuſing, without checking them in the fruition of thoſe joys, which are to be their only portion, till at length
Gen. xv. 16. *their iniquity filling up the determinate meaſure*, he cuts them off, in the height of their enjoyments, and employing oft-times their own ſins for their executioners, or at leaſt inſtruments of their deſtruction, precipitates them headlong from the pinacle of their delights, into the bottomleſs pit, which one of their predeceſſors (the rich man in the parable) called, as
Luk. xvi. 28. he ſadly found it, the *place of torment*, where the luſcious ſweets of ſin are ſo dearly reckon-
2 Sam. ii. 26. for, and afford ſo much *bitterneſs in the latter end*, that their ſenſe ſadly convinces them, of (what their ſenſuality kept them from believing) the folly of gaining any thing at the rate of loſing their own ſouls. Thus the Iſraeliti ſh prince found a Nemeſis bold enough to violate the ſanctuary, even of his miſtreſs's arms, and (regardleſs of its charms) enter that lovely circle, their kindneſs cloſed him in, to ſnatch him thence, and extinguiſh the luſt-
Num xxv. ful flames, that lighted him thither, with the cold blaſts of death. Thus the mutinous loathers of manna, and luſters after fleſh, had their wiſh ſeverely granted, for they had indeed quails ſerved in by fields-full, but attended with ſo ſudden and ſharp a reckoning, that *whilſt* Num. xi. *the fleſh was yet between their teeth, ere it was* 33. *chewed*, death hindered them to ſwallow it, choaked them with it, and devoured them as greedily, as they did thoſe birds. Thus the inſolent Philiſtines found themſelves ill protected by their vainly celebrated God, and his Judges xvi. (much ſtronger) temple, though in the latter there were thouſands of them, without any other enemy, than one, they had ſent for to be a friend to their mirth. For in the very midſt of all the triumphs of a ſolemn feſtival (which had more properly been kept to *Dalilah*) whilſt they were inſulting over captive *Sampſon*'s blindneſs, they could not ſee their own approaching deſtiny, though it were then ſo near, that the next fit of laughter had not time to paſs to their mouths, ere an unexpected vengeance (the provoked Deity lending an omnipotent arm to *Sampſon*'s hand) confounded in one ruin) the idol with the worſhippers, and ſuddenly turned the whole temple into an altar, with which the prieſts themſelves fell ſurprized ſacrifices to that tragical ſolemnity. And thus (to haſten from ſo ſad a theme) the revelling *Belſhazzar*, in the midſt of his magnificent and royal feaſt, ſaw an intruding hand, which by its manner of appearing, as well as by what it wrote, was able to mar the ſupper, without imparing the dainties. And that monarch, whom even a ſiege could not reduce below a condition of feaſting, though he were carouzing in the conſecrated cups, had ſuch a brimmer of trembling put into his hand, as both preſaged and, perchance, began the deſtiny approaching him under the enſigns of the noble *Cyrus*, whoſe conquering ſword, guided by providence, and made the ſword of juſtice, did that very ſame night let out his wine, and blood, and life together.

Upon the ſame ſubject.

IT is hard on ſuch an occaſion to avoid making ſome reflection upon the mutability of worldly conditions! How little did this crow imagine, a quarter of an hour ſince, that in ſo ſhort a time, his body ſhould be as ſenſeleſs, and as ſtinking carrion, as that he was wont to feed it with; that his feathers ſhould wear ſo unlucky a kind of mourning for his deſtruction, and that I ſhould write his epitaph with one of his own quills! Sure, ſince a few minutes can turn the healthieſt bodies into breathleſs carcaſes, and put thoſe very things into the hands of our enemies, which were they, that we principally relied on for our ſafety, it were little leſs than madneſs, to repoſe a diſtruſtleſs truſt in theſe tranſitory poſſeſſions, or treacherous advantages, which we enjoy but by ſo fickle a tenure. No; we muſt never venture to wander far from God, upon the preſumption, that death is far enough from us; but rather in the very height of our jollities, we ſhould endeavour to remember, that they, who

feaſt

feaſt themſelves to-day, may themſelves prove feaſts for the worms to-morrow.

REFLECTION IV.

At Lees. *Upon a glow-worm, that he kept included in a cryſtal phial.*

IF this unhappy worm had been as deſpicable as the other reptiles, that crept up and down the hedge, whence I took him, he might, as well as they, have been left there ſtill; and his own obſcurity, as well as that of the night, had preſerved him from the confinement he now ſuffers. And if, as he ſometimes for a pretty while withdrew that luminous liquor, that is as it were the candle to this dark lanthorn, he had continued to forbear the diſcloſing of it, he might have deluded my ſearch, and eſcaped his preſent confinement.

RARE qualities may ſometimes be prerogatives, without being advantages. And though a needleſs oſtentation of one's excellencies may be more glorious, yet a modeſt concealment of them is uſually more ſafe: and an unſeaſonable diſcloſure of flaſhes of wit may ſometimes do a man no other ſervice, than to direct his adverſaries, how they may do him a miſchief.

AND as though this worm be lodged in a cryſtalline priſon, through which it has the honour to be gazed at by many eyes, and, among them, by ſome, that are ſaid to ſhine far more in the day than this creature does in the night; yet no doubt, if he could expreſs a ſenſe of the condition he is in, he would bewail it, and think himſelf unhappy in an excellency, which procures him at once admiration and captivity, by the former of which he does but give others a pleaſure, while in the latter he himſelf reſents a miſery.

THIS oftentimes is the fate of a great wit, whom the advantage he has of ordinary men in knowledge, the light of the mind expoſes to ſo many effects of other men's importunate curioſity, as to turn his prerogative into a trouble: the light, that ennobles him, tempts inquiſitive men to keep him, as upon the ſcore we do this glow-worm, from ſleeping: and his conſpicuouſneſs is not more a friend to his fame, than an enemy to his quiet; for men allow ſuch much praiſe, but little reſt. They attract the eyes of others, but are not ſuffered to ſhut their own; and find, that by a very diſadvantageous bargain, they are reduced for that imaginary good, called fame, to pay that real bleſſing, liberty.

AND, as though this luminous creature be himſelf impriſoned in ſo cloſe a body as glaſs, yet the light, that ennobles him, is not thereby reſtrained from diffuſing it ſelf: ſo there are certain truths, that have in them ſo much of native light or evidence, that by the perſonal diſtreſſes of the propoſer, it cannot be hidden, or reſtrained; but in ſpite of priſons, it ſhines freely, and procures the teachers of it admiration, even when it cannot procure them liberty.

REFLECTION V.

Upon a court's being put into mourning.

PART I*.

Hague 1648.

GENORIO, EUSEBIUS, LINDAMOR.

GENOR. METHINKS, you look, *Euſebius*, as if the change, that blacks have made in this place, ſince I laſt ſaw you here, tempts you to queſtion, whether or no this be the court.

LIND. Yet, I fear, *Euſebius* will ſcarce doubt, that you, and theſe other gentlemen are courtiers, whilſt he ſees, how much you diſſemble in perſonating ſadneſs: for though your clothes look mournful, your faces do not, and you talk to one another as unconcernedly, as when you wore lighter colours; and your grief is ſo ſlight, that it has not an influence ſo much as upon your looks, and words, which yet are things, that courtiers are ſaid to be able to diſguiſe without an over-difficult conſtraint.

GENOR. But, I hope, *Lindamor*, I need not labour to perſuade ſuch as you, that, when we ſeem to mourn, without doing it, we may be thought guilty of diſſimulation, without being ſo: for what duty is there, that you and I ſhould be really troubled for the death of a prince, whoſe ſubjects we were not, who never obliged us, and who perhaps did only keep the power of doing good, which himſelf never uſed, from a ſucceſſor, that had the will to employ it? But you will demand, why then we put on black; to which the anſwer is eaſy, that cuſtom having eſtabliſhed that ceremony in the courts of princes, in amity with each other, the omiſſion would be looked upon as an affront, and be a provocation. And therefore, the blacks we wear, are not meant to expreſs a grief for the dead, but a reſpect to their living relations: and thus, this as heartleſs as ſolemn ſhew of mourning is not put on by hypocriſy, but by prudence, or civility. And in this caſe, I would appeal to *Euſebius* himſelf, but that I perceive ſome object or other has, ever ſince we began to talk, engroſſed his attention, as well as ſealed up his lips.

LIND. I have taken notice of it, as well as you, *Genorio*, and I confeſs, I would give much to learn his thoughts.

EUSEB. It is odds then, *Lindamor*, that you would over-purchaſe ſo worthleſs a knowledge: and to ſatisfy your curioſity at an eaſier rate, I will tell you, that I was obſerving, how a gentleman, who, it ſeems, does not much frequent the court, chancing to come in a coloured ſuit, that, but laſt week, would have been thought a fine one, was ſtared at by all in the room except your ſelves, whoſe faces chanced to be turned from him, like a man of another country, (not to ſay of another world;) which the poor gentleman at length perceiving, he ſoon grew ſo ſenſible of it, that in ſpite of the richneſs and newneſs of his clothes, with many bluſhes he ſlunk out of the court, to which he found

* For there was a ſecond part of this reflection, but when it was to be ſent to the preſs it could not be found, nor would the preſs's haſte, and the author's occaſions, allow him either to ſtay till it were found, or write a new one.

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found men's gazing at him concluded him to be a ſtranger.

LIND. But this, *Euſebius*, is only to tell us, what you obſerved, not what reflections you made upon it; and you know, that which I was inquiſitive after, was your thoughts.

EUSEB. I will add then, *Lindamor*, ſince you will have it ſo, that I was conſidering, that there has been no law made by the ſtate to forbid any, much leſs ſtrangers, to appear in this court in coloured clothes: and thoſe, which the gentleman I was ſpeaking of, had on, were ſuch, both for fineneſs, and faſhionableneſs, as would very well become a greater court, if it were not in mourning. But, now the prince, and thoſe, that have the honour to belong to him, or to frequent this place, have put themſelves into blacks, to appear in another, though in a finer habit, is, to betray one's not belonging to the court, nor uſing to come to it; and among ſo many, that think they have a right to give laws in point of clothes, a laced, or an imbroidered ſuit, though laſt week in requeſt, would, now they have laid them by, make a man look not ſo much like a courtier, as a player. And this reflection invited me to conſider further, what a ſtrange influence faſhions have on mankind, and what an happy change might be eaſily made in the world, if they, who have it in their power to introduce cuſtoms, would make it their endeavour to introduce good ones.

LIND. I am ſo much of your mind, *Euſebius*, that I confeſs, I envy not princes ſo much for the ſplendour and the pleaſures; that they live in, nor for the authority of raiſing armies, nor, perchance, for the happineſs of making them victorious, as for the power of impoſing and reforming of faſhions. And I think it a leſs improvable prerogative, to be able to coin any metal into money, or call it in at pleaſure, than by the ſtamp of their authority to introduce good cuſtoms, and make them current.

GENOR. But, do not princes enough, when they take care to make good laws, and ſee them well executed?

LIND. I will not diſpute, whether by that, they do all they ought, but ſure I am, they do not all they may: for human laws being made for the civil peace of human ſocieties, they are wont to be framed not for the making men virtuous, but the reſtraining them from being miſchievous; they conſiſt far more of prohibitions than commands, and even their prohibitions reach but to a little part of what is ill; the buſineſs of laws being to provide, not againſt all evils, but thoſe groſſer ones, that are prejudicial to civil ſocieties: ſo that there are a thouſand rules of reaſon, or Chriſtianity, which ſtates have not thought fit to turn into laws. For pride, envy, covetouſneſs, gluttony, intemperance, effeminateneſs, oaths, idleneſs, and I know not how many other ſins, contrary to the laws of nature, and of Chriſt, are ſo little provided againſt by human ſanctions, that one may be a bad Chriſtian, and a bad man, without being a bad citizen; there being nothing more eaſy, nor, I fear, more uſual, than for multitudes to paſs uncited before man's tribunal, to receive their condemnation at God's. But though a prince can ſcarce, as a legiſlator, prevent, or ſuppreſs ſuch ſins, yet, as a pattern, he may do much towards it: for by his example, his opinions, his encouragements, and his frowns, he may reform an hundred particular things, which the laws do not (and perhaps cannot) reach. His declared eſteem of ſuch and ſuch practices, joined with his particular actions ſuited to it, and his profeſt diſlike of thoſe ſinful or diſhonourable courſes, he finds the rifeſt, backed with a ſteady and reſolute diſcountenance of thoſe, that do not decline them, will, in a ſhort time, bring thoſe, that are about him, to conform their actions and behaviour to what men are ſatisfied he deſires, or likes. And thoſe, whom their nearneſs to him, or their employments, make the conſpicuous and exemplary perſons, being thus modeled, their relations and dependants will quickly be ſo too; and then that which is in requeſt at court, being upon that very account looked upon as the faſhion, it will by degrees be imitated by all thoſe, on whom the court has influence; ſince, as we juſt now ſaw in the inſtance of *Euſebius*'s gaudy gentleman, men will be aſhamed to be unlike thoſe, whoſe cuſtoms and deportments paſs for the ſtandards, by which thoſe of other men are to be meaſured.

REFLECTION VI.

Upon hearing of a lute firſt tuned, and then excellently played on.

THE jarring ſtrings made ſo unpleaſant a noiſe, whilſt the inſtrument was tuning, that I wonder not at the ſtory, that goes of a Grand Signior, who being invited by a Chriſtian embaſſador to hear ſome of our muſick, commanded the fidlers to be thruſt out of his ſeraglio, upon a miſ-apprehenſion, that they were playing, when they were but tuning. But this rare artiſt had no ſooner put an end to the ſhort exerciſe he gave our patience, than he put us to the exerciſe of another virtue; for his nimble and ſkilful fingers make one of the innocenteſt pleaſures of the ſenſes to be one of the greateſt, and this charming melody (for which *Orpheus* or *Orion* themſelves might envy him) does not ſo properly delight as raviſh us, and render it difficult to moderate the tranſports of our paſſions, but impoſſible to reſtrain the praiſes, that expreſs our ſatisfaction: ſo that if this muſician had been diſcouraged by the unpleaſant ſounds, that were not to be avoided, whilſt he was putting his lute in tune, from proceeding in his work, he had been very much wanting to himſelf, and to ſave a little pains, had loſt a great deal of pleaſure and applauſe.

THUS, when the faculties and paſſions of the mind, either through a native unrulineſs, or the remiſſneſs of reaſon and conſcience, are diſcompoſed, he, that attempts to bring them into order, muſt expect to meet at firſt but an uneaſy taſk, and find the beginning of a reformation more troubleſome, for the time, than the

paſt diſorders were: but he is very little his own friend, if he ſuffers theſe ſhort-lived difficulties to make him leave his endeavours unproſecuted; for when once they have reduced the untuned faculties and affections of the ſoul to that paſs, which reaſon and religion would have them brought to, the tuned or compoſed mind affords a ſatisfaction, whoſe greatneſs does even at preſent abundantly recompence the trouble of procuring it, and which is yet but a prelude to that more raviſhing melody, wherein the ſoul (already harmonious within itſelf) ſhall hereafter bear a part, where the harps of the ſaints accompany the glad voices, that ſing the ſong of the lamb, and the alleluiahs of the reſt of the celeſtial choir.

REFLECTION VII.

Upon being preſented with a rare noſegay by a gardener.

LINDAMOR, EUSEBIUS.

LIND. HERE is indeed a preſent, for which I muſt ſtill think myſelf this fellow's debtor, though he thinks I have overpaid him. It is pity theſe rarities were not more ſuitably addreſſed, and worn by ſome of nature's other maſter-pieces, with whom they might exchange a graceful luſtre, and have the ornament they confer reflected back upon them. But one, that had never been a lover, would perhaps ſay, that that wiſh were more civil to the flowers, than the ladies, of whom there are few, which theſe ſoft poliſhed ſkins, and orient tinctures, would not eaſilier make foils, than prove ſuch to them: for (not to name the reſt) this lovely fragrant roſe here wears a bluſh, that needs not do ſo, at any colour the ſpring itſelf can, amongſt all her charming rarities, ſhew. Yes, here are flowers above the flattery of thoſe of rhetorick; and beſides, two or three unmingled liveries, whoſe ſingle colours are bright, and taking enough to exclude the wiſh of a diverſity, here is a variety of flowers, whoſe dyes are ſo dexterouſly blended, and fitly chequered, that every ſingle flower is a variety. I envy not *Arabia*'s odours, whilſt that of this freſh bluſher charms my ſenſe, and find my noſe and eyes ſo raviſhingly entertained here, that the bee extracts leſs ſweetneſs out of flowers; which were they but leſs frail, I fear would make me more ſo than yet I am. Surely this gardener leads a happy life! He inherits nothing of *Adam*, but that primitive profeſſion, that imployed and recompenced his innocence, and ſuch a gay and privileged plot of his *Eden*, as ſeems exempted from the general curſe, and inſtead of the thorns and thiſtles, that are the unthankful earth's wonted productions, brings him forth lillies and tulips, and gratefully crowns his culture (for toil I cannot think it) with chaplets of flowers.

EUSEB. I perceive, (*Lindamor*) that you judge of the delightfulneſs of this man's calling, only by theſe lovely and fragrant productions of it. And you ſee theſe curious flowers in their prime, without ſeeing by what practices, and degrees, they have been brought from deſpicable ſeeds to this perfection and luſtre. And perhaps, if you conſidered, that a gardener muſt be digging in the violent heats of the ſummer, and muſt be afraid of the bitter cold of the winter, and muſt be watchful againſt ſurpriſing froſts in the ſpring, and muſt not only prune, and water, and weed his ground, but muſt, to obtain theſe gaudy and odoriferous flowers, ſubmit to deal with homely and ſtinking dung: if (*Lindamor*) you would take notice of theſe and of ſome other toils, and hardſhips, that attend a gardener's trade, you would (I doubt not) confeſs, that his imployments, like his buſhes, bring him thorns as well as roſes.

AND now give me leave (*Lindamor*) to tell you, that this may be applied to the condition of ſome ſtudious perſons, that you and I know. For when we hear a learned or eloquent ſermon, or read ſome book of devotion, or perhaps ſome occaſional diſcourſe handſomely written, we are apt to envy the preacher or the writer, for being able to ſay ſome things, that inſtruct or pleaſe us ſo much. But alas, (*Lindamor*) though we ſee not theſe productions of the brain till they are finiſhed, and conſequently fitted to appear with their full advantages abroad; yet to bring them to that paſs, the author may perhaps undergo many a trouble, that we dream not of. For he, that has to do with difficult or weighty ſubjects, cannot preſent us a good book, or a fine diſcourſe, with the ſame eaſe, that a rich man can preſent us a fine pair of gloves, or a fine collation, which may be had at an hour's warning from the next milliner's or confectioner's. For to be able to write one good book on ſome ſubjects, a man muſt have been at the trouble to read an hundred: to grow capable to give a better rendering of a Greek text, he muſt, perchance, have peruſed *Suidas*, *Stephanus*, *Heſychius*, and I know not how many lexicographers and ſcholiaſts: to be qualified to make a tranſlation of an Hebrew word or phraſe, that ſhall illuſtrate a dark text, or clear a difficulty, or more fitly agree with his notion, or accommodation of a place in Scripture, a man muſt have not only, like a ſchool-boy, learned an Hebrew grammar, and turned over *Buxtorf*'s, *Schindler*'s, and other dictionaries, but (which is worſe) he muſt, in many caſes, hazard his eyes and his patience in converſing with ſuch Jewiſh writings, not only as *Elias* his *Tiſhbi*, and *Kimchi*'s *Michlol*; but to gain a little rabbinical learning, and find out ſome unobvious ſignification of a word or phraſe, he muſt devour the tedious and voluminous rhapſodies, that make up the Talmud, in many of which he can ſcarce learn any thing, but the art of ſaying nothing in a multitude of words; and in others, which are not ſo uſeleſs, the moſt he will find in I know not how many dull pages, (written with as little wit as truth) will perhaps be an account of ſome wild opinion, or ſome obſolete cuſtom, or ſome ſuperſtitious rite of a generation of people, whoſe fancies and manners ſcarce any thing makes worth our inquiring after, but their having lived many ages ſince. And even

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when a man ſets himſelf to write thoſe ſmooth compoſures, where eloquence is conſpicuous, and ſeems to be chiefly deſigned, the author ſeldom comes by his contentment on as eaſy terms as the readers come by theirs. For, not to mention, that ſometimes periods, that in a well-printed book look very handſomly, and run very evenly, were not in the written copy without interlining and tranſcriptions; thoſe, that are ſcholars themſelves, can hardly write without having an ambition, or at leaſt a care, to approve their diſcourſes to them that are ſo too. And in the judgment of ſuch peruſers, to be able to write well, one muſt not only have ſkill in the ſubject, but be well ſkilled in the way of writing, leſt the matter be blemiſhed by the manner of handling it. And although to ſhew one's ſelf a maſter, in treating of variety of themes with a florid ſtyle, and even in thoſe compoſures, that are deſigned chiefly to expreſs wit and move affections, one may think, that nature may be well let alone to ſupply any ſhe has been kind to, with all they need, yet even in theſe caſes there are ſome toils and uneaſineſſes, that are ſcarce to be avoided; ſince a diſcreet man, though never ſo rich in nature's gifts, will think himſelf obliged to ſtudy rhetorick, that he may be ſure he does not tranſgreſs the laws of it. For though an author's natural parts may make his book abound with wit, yet without the help of art he will ſcarce make it free from faults. And to be well ſtocked with compariſons, which, when ſkilfully managed, make the moſt taking paſſages of fine pieces, one muſt ſometimes ſurvey and range through the works of nature and art, which are the chief warehouſes, where variety and choice of ſimilitudes is to be had; and to obtain thoſe pleaſing ornaments, there is oftentimes required no leſs pains than to deviſe uſeful notions. As one muſt ſearch the ditches amongſt briars and weeds, not only to find medicinable herbs, but to gather primroſes and violets. So that (*Lindamor*) to conclude, if we conſider the trouble, that applauded compoſures do oftentimes coſt their authors, we ſhould be ſenſible we owe more, than moſt men think we do, to thoſe, to whom we owe good books. But then unleſs they find ſome recompence for their labours, in the ſatisfaction of promoting piety, or in the well-natured pleaſure they feel themſelves in pleaſing others, I ſhould ſcarce doubt, but that ſome of the writers, we think ſo happy, may rather deſerve our eſteem than our envy.

REFLECTION VIII.

Upon a child that cried for the ſtars.

I REMEMBER *P. S.* did once, upon juſt the like theme, diſcourſe to the following purpoſe.

AMONGST thoſe numerous eyes, that theſe fair lights attract in ſo clear a night as this, there are not perhaps any, that are more delighted with them, than this child's ſeem to be. And thoſe Perſians, that adored the riſing ſun, could not be more charmed with that glorious object, than this child is with theſe twinkling lights, that need his abſence to become ſo much as viſible. But his is a pleaſure, that is not more great than unquiet, for it makes him querulous, and unruly; and becauſe he cannot by his ſtruggling, and reaching forth his little hands, get poſſeſſion of theſe ſhining ſpangles *, that look ſo finely, their fires produce water in his eyes, and cries in his mouth, that are very little of kin to the muſick the Platoniſts fancied in the ſpheres he looks at. Whereas, though my inclinations for aſtronomy make me ſo diligent a gazer on the ſtars, that in ſpite of my great obnoxiouſneſs to the inclemency of the nocturnal air, I gladly ſpend the coldeſt hours of the night in contemplating them; I can yet look upon theſe bright ornaments of heaven it ſelf, with a mind as calm and ſerene, as thoſe very nights, that are fitteſt to obſerve them in.

I KNOW divers men, for whom nature ſeems to have cut out too much work, in giving them, in an unconfinedly amorous diſpoſition of mind, ſtrong appetites for almoſt all the fair objects, that preſent themſelves to their ſight: theſe amorous perſons may be, I grant, very much delighted, when they firſt gaze upon a conſtellation of fair ladies; but the heart commonly pays dear for the pleaſure of the eye, and the eager deſires, that beauty creates, are in ſuch men excited too often not to be frequently diſappointed, and are wont to be accompanied with ſo many jealouſies, and fears, and repulſes, and difficulties, and dangers, and remorſes, and deſpairs, that the unhappy lovers (if thoſe, that love more than one, can merit that title) do rather languiſh than live, if you will believe either their own querulous words, or their pale and melancholy looks, which would make one think they were juſt entering into the grave, or had been newly digged out of it. Whereas a perſon, that has his affections and ſenſes, at that command, which reaſon and religion require and confer, can look upon the ſame objects with pleaſed but not with dazled eyes: he conſiders theſe bright and curious productions, as fair animated ſtatues of nature's framing, and contenting himſelf to admire the workmanſhip, adores only the divine artificer, whoſe infinite amiableneſs is but faintly ſhadowed forth even by ſuch lovely creatures. And therefore what has been ſaid of miſtreſſes, may be more juſtly applicable to all the other objects of men's too eager paſſions. To be ſhort, looking upon theſe curiouſeſt productions of nature, with a philoſopher's and a Chriſtian's eyes, he can caſt them on thoſe bright objects with pleaſure, and yet withdraw them without trouble, and allowing beauty to contribute to his delight, without being able to create him any diſquiet; though it afford him a leſs tranſporting pleaſure than it ſometimes does the amoriſt, yet, all things conſidered, it may afford him a greater pleaſure, by being more innocent, more untroubled, and more laſting; and there may be ſuch a difference betwixt the contentment of this calm admirer

* Thus in a ſtarry night fond children cry
For the rich ſpangles, that adorn the ſky. Mr. *W.*

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mirer of beauty, and that of a greedy and unconfined proſtitutor of his heart to it, as there is betwixt the unquiet pleaſure, that the ſight of the ſtars gives to this child, and the rational contentment it may afford to an aſtronomer.

REFLECTION IX.

Upon my lady D. R. *her fine cloſet.*

LINDAMOR, EUSEBIUS.

A. D. 1651. LIND. IS not this cloſet ſtrangely fine, *Euſebius?* Here is ſuch a variety of pretty and taking objects, that they do as well diſtract the eye as delight it; the abundance, the choice, and the order, do as well diſcloſe the fair poſſeſſor's ſkill, as her magnificence, and ſhew at once, that ſhe both has plenty, and deſerves it, by knowing ſo well how to make uſe of it. Thoſe things, that are here ſolitary, or ſingle, will ſcarce be elſewhere matched; and all the reſt are ſo pretty, and ſo excellent in their ſeveral kinds, that the number of fine things, that make up this curious collection, cannot hinder any of them from being a rarity. And in a word, the embelliſhments, that adorn and ennoble this delightful place, are ſuch, that I believe the poſſeſſor of them, as welcome as ſhe is unto the beſt companies, ſcarce ever looks upon finer things, than ſhe can ſee in her cloſet, unleſs when ſhe looks into her glaſs. But, methinks, *Euſebius*, you hear and view all this with a ſilent ſeriouſneſs, which begins to make me ſuſpect, that what I thought might be an effect of your wonder, may be ſo of your diſlike.

EUSEB. The collection, *Lindamor*, is, I confeſs, very curious in its kind, and ſuch as if the miſtreſs of it were leſs handſome than ſhe is, might give her as well cauſe to be jealous of theſe fine things, as to be proud of them, ſince a beauty, that were but ordinary, could not divert a ſpectator's eye from objects, whereof many are not ſo. But, *Lindamor*, I muſt freely tell you, that I like both the lady, and the cloſet, much better than the cuſtom ſuch ſights as theſe are introducing among ladies of furniſhing ſuch kind of cloſets: I know, that youth may in certain caſes, excuſe ſome of the impertinencies it is wont to occaſion; and it is not ſtrange to me, that perſons of the fairer ſex ſhould like, in all things about them, that handſomeneſs, for which they find themſelves to be the moſt liked; nor would I forbid, even ſuch of them, as are not of a very high quality, to have a retiring place ſo neatly adorned, as may invite them to be alone, and withdraw to it, to read, or meditate, provided theſe ornaments be not ſo coſtly, as to rob charity, or ſo gaudy, as to diſtract the devotion they ſhould but accommodate. And in caſe circumſtances ſhould ſo conſpire, as that youth and quality ſhould be attended by ſuch a plentiful fortune, as that after all, that either juſtice, prudence, or decency can challenge, there remains yet enough, both to relieve the poor, and purchaſe rarities themſelves; I will not be ſo ſevere, as to condemn perſons ſo circumſtanced, nor fall out with thoſe, that are able to reconcile ſumptuouſneſs and charity. But the number of ſuch ladies, eſpecially ſo ſoon after a long civil war, muſt needs be but ſmall, and I fear much inferiour to that of thoſe, who will conſider more what they ſee done before their eyes, than they will the diſparity of circumſtances betwixt their own condition, and that of thoſe they emulate: and the greater appearance of ingeniouſneſs, as well as innocence, there is in the practice I am diſapproving, the more dangerous it is, and the more fit to be examined and decryed. For as the old ſerpent has variety of wiles, ſo he fits them to the various tempers of the perſons he aſſays to work upon; and when he meets with ladies virtuouſly diſpoſed, ſince he cannot quite eradicate their inclinations to the beſt part of religion, charity, he will at leaſt blaſt and render them fruitleſs; and he juſtly thinks, he has reached no ſmall part of his end, if though he cannot ſeduce them to do ill, he can at leaſt hinder them from doing good. And this he has of late attempted but too proſperouſly, by perſuading us to take thoſe for the ſtandard and examples of our expences, that making none of the ſcore of piety, have the more left for their vanities and their appetites; which they gratify at ſuch high rates, that thoſe, that think themſelves bound to imitate them in thoſe exceſſes, that are miſnamed gallantry, ſhall have as little ability as the other have will, to apply any conſiderable part of their eſtates to thoſe uſes, which chiefly God granted them thoſe eſtates for; and by that time, the lady her ſelf, and the houſe, and the cloſet, are furniſhed with all the ornaments, that vanity and emulation call for, there is nothing left for charity to diſpoſe of, nay, perhaps not for juſtice; the creditor being oftentimes turned back empty as well as the beggar, if not alſo made a beggar by ruinous delays. And greater fortunes, than moſt ladies have, may be exhauſted, by gratifying ſuch an ambition, as that of a cloſet, to whoſe coſtlineſs nothing can put limits, till diſcretion do; cuſtom it ſelf having not yet regulated a piece of vanity, which, as impoſing as cuſtom is wont to be, it has not yet dared to enjoin.

LIND. Methinks, *Euſebius*, you are ſomewhat forward to accuſe thoſe fair creatures, that though they ſhould want innocence, would ſcarce want advocates; and you are too good a caſuiſt to ignore, that they are wont to alledge, that the bravery you are ſo ſevere to, is no where expreſsly prohibited in the Scripture; and this unforbiddenneſs they think ſufficient to evince, that the ſumptuouſneſs you ſo condemn, is not abſolutely, and in its own nature, ſinful.

EUSEB. I can readily believe, that *Lindamor* has wit and amorouſneſs enough to make him find it more eaſy to defend fair ladies, than to defend himſelf againſt them; and I know, it is ſaid, that theſe ſumptuous cloſets, and other vanities, are not ſimply unlawful in their own nature: but I know too, that divers things, not in their own nature unlawful, may be made ſo by circumſtances; and if ſo, then I fear, that that can be no other than ill, which makes a man needleſly diſable himſelf to do good. The Apoſtle,

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Apoſtle, that diſcountenanced women's wearing of gold, or precious things upon their bodies, would ſure have oppoſed their having more ſumptuous ornaments upon their walls: theſe cannot pray for us, but the poor and diſtreſſed, they keep us from relieving, may either ſucceſsfully pray to God for us, or cry to him againſt us. The Scripture, that repreſents *Dives* in hell, without ſaying, that he oppreſſed or defrauded any, gives no other account of his doom, than that living at a high rate, and going richly dreſſed, he neglected to relieve the ſtarving poor. A few ſuch cloſets as this lady's might be eaſily enlarged, and contrived into an hoſpital: a ſmall part of theſe ſuperfluities would relieve the neceſſities of many families, and a liberal heart might purchaſe heaven at an eaſier rate, than the furniture of this cloſet coſt the owner of it. Nor is this practice ſo unallied to a fault, as to eſcape a puniſhment even in this world; theſe courtiers of applauſe being oftentimes reduced to live in want, even in the midſt of a plentiful fortune; theſe coſtly trifles ſo engroſſing all that they can ſpare, that they muſt ſometimes deny themſelves things convenient, and, perhaps, almoſt neceſſary, to flaunt it out with thoſe, that are neither the one nor the other, and being frequently enough fain to immolate their own inclinations and deſires, though, perchance, ſtrong and innocent, to their vanity. And thoſe, that have once found the happineſs there is in making others happy, will think their treaſure better beſtowed in feeding hungry mouths, than idle eyes: the coſtly practice I am yet cenſuring, does not only offend charity, but ſtarve it, by ſubtracting from it that, which ſhould feed it, and enable it to act like it ſelf. And for my part, I think, he, that deviſes, and by his example brings credit to, a new expenſive way of vanity, does really deſtroy more poor, than if he uſurped an alms-houſe, or ruined an hoſpital. And by the ill precedent he leaves, he takes the way to be uncharitable, even after death, and ſo do harm, when miſers and uſurers themſelves are wont (by their legacies) to do ſome good. To conclude, it is no very Chriſtian practice to diſobey the dictates of piety, without having ſo much to plead for ſo doing, as the pretence of following the dictates of cuſtom: and it is a great deal better to be without a gay cloſet, than to be without charity, which lovelieſt of Chriſtian virtues ſhe muſt ſure very much want, that will needleſsly begin a new example to give a bad one.

RELFECTION X.

Upon his ſeeing a lark ſtoop to, and caught with, day-nets.

EUSEBIUS, LINDAMOR.

EUSEB. POOR bird! thou wert juſt now ſo high upon the wing, that the tired gazers feared thou hadſt loſt thy ſelf in heaven, and in thy fatal ſtooping ſeemeſt to have brought us thence a meſſage, that ſo reliſhes of that place, that I ſhould be troubled to ſee thee ſo rudely entertained, if that circumſtance were not neceſſary to the inſtructions of thy meſſage. Some birds, you know, *Lindamor*, we uſually beguile with chaff, and others are generally drawn in by appropriated baits, and by the mouth, not the eye. But the aſpiring lark ſeems compoſed of more ſprightly and refined materials; ſhe is ever a natural, though no native, Perſian; and the ſun makes not a cloudleſs viſit to our horizon, which that grateful creature gives not a welcome to, both by notes, which, could he hear them, he would think worthy of him, and by a flight as aſpiring, as if ſhe meant he ſhould hear them; and, in a word, ſo conſpicuous is this creature's fondneſs of light, that fowlers have deviſed a way to catch her by it, and pervert it to her ruin: for placing broken looking-glaſſes upon a moveable frame betwixt their nets, the unwary bird, while ſhe is gazing upon that glittering light the glaſs reflects, and ſporting herſelf in thoſe beams, which derive a new glory from their very being broken, heedleſsly gives into the reach of the ſurprizing nets, which ſuddenly cover her, and which the light it ſelf kept her from ſeeing. The devil is like this fowler, *Lindamor*; and you, or I, had perhaps reſembled the unhappy lark, if ſometimes providence did not both graciouſly, and ſeaſonably, interpoſe, and even when we were come near enough to have been covered by the nets, reſcued us from them; for it has ever been that old ſerpent's policy, and practice, to take the exacteſt meaſure of our inclinations, that he may ſkilfully ſuit his temptations to them; well knowing, that that dexterity gains him a devil within us, that conſpires with him without us, to make us inſtances of that truth, which repreſents things divided againſt themſelves as ruinous. If therefore the tempter find by experience, that you are indiſpoſed to be wrought upon by common temptations, to forget the practice of religion, that you have unconcernedneſs enough not to be much diſtracted with the empty and trifling chaff, youth is wont to be caught with, (which perhaps ſeldom employ any of your thoughts ſo much as thoſe of ſcorn, and pity) that the very gain and ſolider goods of this world (for which many, thought wiſe men, loſe thoſe of the next) cannot make you ſo greedy, nor ſo fond of them, as he deſires: if, I ſay, the devil have ſufficiently obſerved, how uneaſy it were to intice you with common baits, he will alter his method ſtrait, and attempt to catch you with light. He knows as well as I do, that you have a curioſity, or rather a greedineſs of knowledge, that is impatient of being confined by any other limits than thoſe of knowledge it ſelf; and accordingly, ſeldom, or perhaps never diſturbing or frightening you, he will let you freely ſport your ſelf about the glittering intellectual glaſs, men call philoſophy, and ſuffer you not only to gaze upon all its pieces, and ſurvey a pretty number, but, peradventure, pry into more than one: and among ſo numerous, and delighting objects, I fear, that if you will frankly own what my own guilt makes me ſuſpect you of, you muſt confeſs, that he had made you ſo ſhare your time, that you ſhould ſcarce have left your ſelf

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any for heavenly themes, and the meditation of death, (which conſequently, might have then ſurprized you, had it invaded you) if providence had not mercifully ſnatched you out from between the nets you were allured to, before you were quite involved in them; and by ſickneſs, or elſe, by means (in other caſes) ſo unlikely, as outward diſtractions, called your thoughts home by driving them away from thoſe enchanting ſtudies, whoſe light might much likelier have betrayed you into the net, than have ſhewn it you.

LIND. Though I am not ſurprized to hear *Euſebius*, yet I am glad to hear a ſcholar talk at this rate, and believe with you, that many a one, that was neither crow, nor woodcock, has periſhed in this ſnare; and we have known but too many great ſcholars ſo intirely taken up with writing, and reading of books, with learning this ſcience, and with teaching that, that by ſetting themſelves ſuch taſks, as required and employed the whole man, death has undiſcernedly ſtollen upon them, and unawares intruded into their ſtudies, where their reſtleſs ambition to inrich the mind never left them the leiſure to prepare it to leave the body, but either made them ſurprized inſtances of that ſad (but true) obſervation of *Seneca*, *pleroſque in ipſo vitæ apparatu vita deſtituit*; or elſe made their condition like that of *Archimedes*, who was ſo buſy in tracing his circles, that he took no notice of that victorious enemy, that came to diſpatch him.

EUSEB. I allow, that it is the innocence, as well as pleaſure of knowledge, that deceives thoſe learned men; but they, as well as others, muſt remember, that even the wholſomeſt meats may be ſurfeited on, and there is nothing more unhealthy, than to feed very well, and do but very little exerciſe. And I take it to be as true of the intellectual, as the material world, that *it profits not a man, if he gain the whole world, and loſe his own ſoul.* Whatſoever therefore philoſophers do tell us of a wiſe man, that he is no where baniſhed, becauſe he is a citizen of the world; I muſt think a Chriſtian every where an exile, becauſe he is a citizen of the heavenly *Jeruſalem*, and but *a ſtranger and a ſojourner here.* It was not abſolutely in the capacity of the *father of lyes*, that the devil boaſted, that the earth was his dominion; for, as our Saviour ſtiled him, *the prince of this world*, I find, that he has all things here ſo much at his devotion, that there is no place, that he cannot lay an ambuſh in, ſince he can pervert even light it ſelf, to hide his ſnares. Let us, therefore, hereafter endeavour ſtill to ſtand upon our guard, as remembering our ſelves to be in an enemy's country, where diſtruſt is the only mother of ſafety; and ſince providence has ſo graciouſly preſented us a leſſon, our books would not have taught us, againſt ſuch a fondneſs of them, as is injurious to piety, and dangerous to the ſoul; let us juſtify, better than this ſilly lark has done, that ſaying of *Solomon*, *ſurely in vain the net is ſpread in the ſight of any bird.* Let not philoſophy any more take up our life ſo, as not to leave us leiſure to prepare for death, and ſtudy a ſcience, which ſhall moſt benefit us in another world, and which alone will do ſo there. No, we may viſit *Athens*, but we ſhould dwell at *Jeruſalem*; we may take ſome turns on *Parnaſſus*, but ſhould more frequent mount *Calvalry*; and muſt never ſo buſy our ſelves about thoſe *many things*, as to forget that *unum neceſſarium*, *that good part, which ſhall not be taken away from us.*

OCCASIONAL REFLECTIONS.

The Laſt SECTION.

REFLECTION I.

Seeing a child picking the plumbs out of a piece of cake his mother had given him for his breakfaſt.

EUSEBIUS, LINDAMOR.

EUSEB. THIS child is ſo much one in his humour, that deſpiſing meer bread, though never ſo nouriſhing and wholeſome, his mother is fain to diſguiſe the materials of it into cake, out of a belief, that the toothſome would make the nutritive part go ſmoothly down. But this liquoriſh chit, I ſee, defeats her plot, and knows already how to nibble off the bait from the hook, and caſting by the meat, makes his whole meal of what was meant only for ſauce, to give a reliſh to what he rejects for it. This puts me in mind of the unwelcome fate thoſe papers of mine, that treat of devotion, have met with: for when I firſt was ſo unacquainted with the world, as to expect, that piety and virtue were able, by their native charms, ſo much to endear my dreſs, as to win themſelves adorers in a plain, or even a ſevere one; I ventured ſome of them abroad, though not in print, yet among my acquaintance, in a careleſs matron-like habit, in which I ſoon found they almoſt frighted moſt of thoſe I had deſigned them to work the quite contrary effects on. But when my acquaintedneſs with the genius of the age had ſadly taught me, that I was to alter my method, that the eloquence of virtue's ſermons was that, which muſt attract an auditory, and engage attention to them; and that thoſe orders of hers, in which ſhe employed not rhetorick for her ſecretary, could not be ſo much as liſtened to, much leſs obeyed, I endeavoured to cloath virtue, though not in a gaudy, in a faſhionable habit, and diveſting her not only of her ſackcloth, but her blacks, where I ſaw ſhe appeared in them with diſadvantage, I endeavoured to give

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give her as much of the modern ornaments of a fine lady, as I could, without danger of being accuſed to have dreſſed her like a courtezan. This attempt having not proved ſo unſucceſsful, but that many were pleaſed to aſſure me, I had not been unlucky in it, I ſpent ſome time in the ſelf-denying exerciſe of minding words, and improving a ſtyle, I hoped to be able to improve to virtue's ſervice, and ſubduing my inclinations to be fit to teach, as I had done to learn, her precepts; I ſometimes, for her ſake, tired my pen in a ſmoother, and more florid ſtyle, than that, which the nature of the ſtudies I was moſt addicted to, made the moſt familiar to me; flattering myſelf with a belief, that ſince my writings had uſually the good fortune not to be ill approved, I might ſo happily mingle and interweave inſtructions with delight, as to neceſſitate my readers to ſwallow both together, or at leaſt bribe them by the latter to entertain the former.

LIND. You have better luck, as well as better ſkill, than many others, if you find it not often to fare with the fiſhers of men, as it did with thoſe other fiſhers, that firſt were honoured with that glorious title, when they com-
Luke v. 5. plained to our Saviour, that *we have toiled all the night, and have taken nothing*. For I ſee, that men are grown witty enough to elude what they cannot deſpiſe, and reſemble the deaf adder, that ſtops her ſpiritual ears from hearkening to the voice of charmers, be the charmer never ſo cunning. And the beſt reception, that the movingeſt eloquence, that pleads for piety, can obtain of them, is but ſuch as may ſerve to make that applicable to the preacher, which God once ſaid to a prophet, *Lo, thou art unto them as a very lovely ſong of one, that hath a pleaſant voice, and can play well upon an inſtrument; for they hear thy words, but they do them not.* But the beſt is, that you ſerve a maſter, that is as inclinable to reward, as able to diſcern, intentions, and does not make his eſtimates by events, but judges of our performances, not by the effects they produce, but the affections they flowed from, and the ends they aimed at.

EUSEB. *The diſciple is not above his maſter, nor the ſervant above his lord.* And therefore, *Lindamor*, as I dare not repine at the unſucceſsfulneſs of my endeavours, ſo I dare think, that whilſt it proceeds but from the obſtinacy of others, it is not likely to be imputed to me by him, that complained himſelf, *that all the day long he had ſtretched forth his hands to an unperſuadable and gain-ſaying people.* Otherwiſe, I confeſs, I ſhould not have much cauſe to be ſatisfied with the return, that all my endeavours have hitherto brought me home. For I ſee, that men can read a book of devotion as unconcernedly as they do a romance or a play, in both of them culling out only what they call wit, and making no better uſe of it than either to exerciſe or improve their own. They hear the moſt pathetick ſermons, not as Chriſtians but orators; and if in ſuch diſcourſes they have been ſo juſt as to praiſe the rhetorick, they think they may well be excuſed, if they over-look the divinity: in ſhort, nothing but what gratifies their fancy can leave any impreſſions on their memory, and that itſelf, if it tend to reform them, makes none on their affections. And ſome, whoſe happier pens allow them to do it far more juſtly than I can, do complain, that if a devout book have not good ſtore of witty paſſages, they will not mind it at all; and if it have, they will mind nothing elſe.

So that, *Lindamor*, I ſhould ſometimes be diſcouraged from proſecuting endeavours, which though they now and then ſucceed, are oftentimes ſo unproſperous, if I did not think with you, that they, who labour to win ſouls to God, are ſet on work by him, that having no need of our performances, ſeeks in our ſervices but the opportunities of exerciſing his own goodneſs.

REFLECTION II.

Upon the ſight of ſweet-meats very artificially counterfeited in wax.

THE ſhape and colours of the beſt ſweet-meats of theſe kinds are here ſo luckily repreſented by a ſkilful hand, that art ſeems to have deſigned rather to rival nature, than barely to imitate her, and a lover of junkets, that approaches not too near to theſe, muſt have much quickneſs of ſight, or but little of appetite, if ſuch inviting objects do not tempt him both to miſtake and to deſire them. But, though at this diſtance theſe alluring ſweet-meats appear very pleaſing, yet if one ſhould be ſo unadviſed, as to endeavour to eat them, inſtead of injoying them more fully by the taſte than he did by the ſight, he would both ſpoil and disfigure them, and perhaps be ſo near choaking himſelf, that he would more earneſtly wiſh them out of his mouth, than ever he wiſhed them in it.

THERE are ſome pleaſures and conditions too in the world, which make ſo fine a ſhew at a diſtance, that in thoſe, that gaze at them aloof off, they frequently beget envy at them, and wiſhes for them; and yet he, that calmly beholds them, takes the beſt way of injoying them: ſince that, which, whilſt it is but aimed at, is expected to be but very ſatisfactory upon a nearer and fuller fruition, would be ſo far from proving ſo, and would ſo little be as ſweet to the palate as ſpecious to the eye, that it would not only ceaſe to afford them any delight, but would make them wiſh they had let thoſe deluding ſweets alone, and would make attainments more uneaſy and troubleſome, than even deſire was.

REFLECTION III.

Upon the eating of oyſters.

EUGENIUS, LINDAMOR.

EUG. WHILST every body elſe is commending theſe oyſters, either with his tongue or with his teeth, ſo that one of the company ſticks not ſay, that they are as much worth, as if they contained each of them a pearl, you only ſeemed as unconcerned a ſpectator,

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ſpectator, as if you thought their proper uſe, like that of flowers, were rather to be looked on than to be eaten.

LIND. I confeſs, *Eugenius*, that I found my ſelf more inclinable to reflect on what you are doing, than to keep you company in it; and whilſt I ſaw ſuch perſons ſo guſtfully ſwallow theſe extolled fiſhes, the ſight led me to take more notice than perhaps you have done of the ſtrange power of education and cuſtom.

EUG. And what, I pray you, has cuſtom to do with oyſters?

LIND. You will ſoon know that, if I tell you, that I was conſidering, on this occaſion, how forward we are to think other nations abſurd or barbarous for ſuch practices, that either the ſame, or little better, may be found unſcrupled at among our ſelves; and I acknowledge it to be one of the chief advantages I account my ſelf to have obtained by my travels, that as I do not eaſily admire, ſo I am not forward to deride, the practice of any people for being new, and am not apt to think their cuſtoms muſt be therefore worſe than ours, becauſe they widely differ from them.

I COULD give you ſtore of inſtances to juſtify this impartiality; but becauſe the circumſtances of eating and drinking are thoſe, which make men, with the greateſt confidence, term other nations brutiſh and barbarous, I will confine my ſelf to ſome examples of that nature.

WE impute it for a barbarous cuſtom to many nations of the Indians, that like beaſts they eat raw fleſh. And pray how much is that worſe than our eating raw fiſh, as we do in eating theſe oyſters? Nor is this a practice of the rude vulgar only, but of the politeſt and niceſt perſons among us, ſuch as phyſicians, divines, and even ladies. And our way of eating ſeems much more barbarous than theirs, ſince they are wont to kill before they eat, but we ſcruple not to devour oyſters alive, and kill them not with our hands or teeth, but with our ſtomachs, where (for aught we know) they begin to be digeſted before they make an end of dying. Nay ſometimes when we dip them in vinegar, we may, for ſauce to one bit, devour alive a ſhoal of little animals, which, whether they be fiſhes or worms, I am not ſo ſure, as I am, that I have, by the help of convenient glaſſes, ſeen great numbers of them ſwimming up and down in leſs than a ſaucer full of vinegar.

WE deteſt and deſpiſe ſome other nations, for feeding upon catepillars, graſhoppers, and other inſects; and others for feeding upon carrion, and ſtinking food.

AND do not many of us do as bad, when we not only eat, but extol, rotten cheeſe, whoſe livid colour ſufficiently betrays its putrefaction, and whoſe odious ſmell offends moſt men's noſes, and turns ſome men's ſtomachs? Nay, when this cheeſe is grown to that high degree of rottenneſs, that our critical palates like it beſt in, we then devour whole hundreds of mites, which are really crawling inſects, bred out of putrefaction, and theſe too are ſo numerous and little, that our greedineſs makes us ſwallow many of them alive.

AMONG the ſavageſt Barbarians we count the Cannibals; and as for thoſe among them, that kill men to eat them, their inhuman cruelty cannot be too much deteſted; but to count them ſo barbarous, merely upon the ſcore of feeding upon man's fleſh and blood, is to forget, that woman's milk, by which alone we feed our ſucking children, is, according to the received opinion, but blanched blood; and that mummy is one of the uſual medicines commended and given by our phyſicians, for falls and bruiſes, and in other caſes too. And if we plead, that we uſe not mummy for food, but phyſick, the Indians may eaſily anſwer, that, by our way of uſing man's fleſh, we do oftentimes but protract ſickneſs and pain; whereas they by their's maintain their health and vigour. And there is no reaſon, why it ſhould be allowable to eat broth, for inſtance, in a conſumption, and be condemnable to feed upon it to maintain health.

BUT laſtly, as the higheſt degree of brutiſhneſs, our travellers mention the practice of the Soldanians, at the *Cape of Good Hope*, who not only eat raw meat, but, if they be hungry, eat the guts and all of their cattle, with the dung in them. I will not anſwer, that I know ſeveral among us, (and perhaps ſome fair ladies too) that, to prevent the ſcurvy and the gout, drink their own or boy's urine: nor that women themſelves do oftentimes take parmacitty inwardly, though the Latin name (*Sperma ceti*) ſufficiently declare what excretion of a whale it is (though perhaps miſtakenly) believed to be: nor yet, that under the name of *Album Græcum*, dog's dung is commonly given to patients of all ſorts and qualities, againſt ſore throats: nor will I mention, that in *Holland* it is uſual, as I have ſeen my ſelf, to mingle ſheep's dung with their cheeſes, only to give them a colour and a reliſh. But I will rather demand, how much leſs we do ourſelves, than what we abominate in thoſe ſavages, when we devour oyſters whole, guts, excrements, and all? nay, when not for phyſick, but only for delicacies, our courtiers and ladies themſelves are wont to make ſauce for the bodies of lobſters of that green ſtuff, which is indeed their dung. And to theſe I could add other examples, if I were not afraid to divert you too long from ſo much pleaſure, as the company ſeems to take, in eating raw fiſh.

EUG. You put me in mind of a fancy of your friend Mr. *Boyle*, who was ſaying, that he had thoughts of making a ſhort romantick ſtory, where the ſcene ſhould be laid in ſome iſland of the ſouthern ocean, governed by ſome ſuch rational laws and cuſtoms, as thoſe of *Utopia*, or the *New Atlantis*; and, in this country, he would introduce an obſerving native, that, upon his return home from his travels made in *Europe*, ſhould give an account of our countries and manners, under feigned names, and frequently intimate in his relations, (or in his anſwers to queſtions that ſhould be made him) the reaſons of his wondering to find our cuſtoms ſo extravagant, and differing from thoſe of his country. For your friend imagined, that by ſuch a way of propoſing many of our

our practices, we ſhould ourſelves be brought unawares to condemn, or perhaps laugh at them, and ſhould at leaſt ceaſe to wonder, to find other nations think them as extravagant, as we think the manners of the Dutch and Spaniards, as they are repreſented in our travellers books.

LIND. I diſlike not the project, and wiſh it were proſecuted by ſomebody, that, being impartial, were more a friend to fables. For when I conſider, that the name of Barbarian was given by the two nobleſt people of the earth, the Greeks and Romans, not only to all the reſt of the world, but to one another, though both thoſe nations were highly civilized, and the courtly Perſians, and other voluptuous Aſiaticks, were perhaps no leſs ſo than they; I doubt, that moſt nations, in ſtyling one another's manners extravagant and abſurd, are guided more by education and partiality, than reaſon; and that we laugh at many cuſtoms of ſtrangers, only becauſe we never were bred to them, and prize many of our own, only becauſe we never conſidered them. And we may well believe, that cuſtom has much a larger empire, than men ſeem to be aware of, ſince whole nations are wholly ſwayed by it, that do not reckon themſelves among its ſubjects, nor ſo much as dream, that they are ſo.

REFLECTION IV.

Upon a lanthorn and candle, carried by on a windy night.

AS there are few controverſies more important, ſo there are not many, that have been more curiouſly and warmly diſputed, than the queſtion, whether a publick or a private life be preferable? But perhaps this may be much of the nature of the other queſtion, whether a married life or a ſingle ought rather to be choſen? that being beſt determinable by the circumſtances of particular caſes. For though, indefinitely ſpeaking, one of the two may have advantages above the other, yet they are not ſo great, but that ſpecial circumſtances may make either of them the more eligible to particular perſons. They, that find themſelves furniſhed with abilities, to ſerve their generation in a publick capacity, and virtue great enough to reſiſt the temptations, to which ſuch a condition is uſually expoſed, may not only be allowed to embrace ſuch an employment, but obliged to ſeek it. But he, whoſe parts are too mean to qualify him to govern others, and perhaps to enable him to govern himſelf, or manage his own private concerns, or whoſe graces are ſo weak, that it is leſs to his virtues, or to his ability of reſiſting, than to his care of ſhunning the occaſions of ſin, that he owes his eſcaping the guilt of it, had better deny himſelf ſome opportunities of doing good, than expoſe himſelf to probable temptations. For there is ſuch a kind of difference betwixt virtue, ſhaded by a private, and ſhining forth in a publick life, as there is betwixt a candle carried aloft in the open air, and incloſed in a lanthorn; in the former place it gives more light, but in the latter, it is in leſs danger to be blown out.

REFLECTION V.

Upon the firſt audience of the Ruſſian extraordinary embaſſador, at which he made his emperor's preſents.

I See the general expectation, that there will be here this night a magnificent appearance, has produced one. And, as it often happens in publick ſhews, that the chief part of them is made by thoſe, that come to ſee them; ſo here, beſides them, whoſe duty obliges them to attend at the ſolemnity, there is a greater concourſe of fine people of either ſex, than any thing of this nature has for theſe many years occaſioned. And not only many of the ladies wear in their ribbands little leſs vivid colours, than thoſe of their faces, and are ſet out with jewels almoſt as ſparkling as their eyes, (which yet the courtiers think were able to warm the Ruſſian hearts, though all the ice and ſnow of their country guarded them) but the men themſelves are many of them as finely and as richly dreſſed, as if even they came as well to be ſeen as to ſee. And if the embaſſador be, what a man of his employment ſhould be, (and what ſome ſay he is) a perſon acquainted with the manners of men, he cannot but know, that we, as other nations, value our own faſhions enough, to look upon men diſguiſed by the Ruſſian dreſs, as little better than anticks, if not as ſome new kind of northern animals. But for all this gazing throng of gaudy ſpectators, that were able to put an ordinary ſtranger out of countenance, to appear in a habit differing from their's; the embaſſador, and thoſe, that come along with him, think it not fit to decline the Ruſſian habit or ceremonies for the Engliſh, but keep to the ceremonies uſed in *Muſcovy*, as ſtrictly, as if the monarch of it, that ſent him hither, ſaw them here; and are not diſcouraged from this manly proceeding, by ſeeing themſelves ſtared at for it by a number of gaudy ſpectators, that wear clothes, and uſe ceremonies, ſo differing from their's. And whatever thoſe may think of the embaſſador, that are wont to eſtimate men by the faſhionableneſs of their clothes; yet the wiſer and more intelligent do not blame him, for refuſing to diſparage the faſhions of his own people, by appearing aſhamed of them; but do rather think it prudent in him, to prefer the pleaſing of his maſter, and his own countrymen, before the gratifying of ſtrangers, ſince it is not here, but at home, that he expects the recompence of his behaviour, and embaſſy.

THUS, when a Chriſtian, who belongs to a celeſtial king, and whoſe *citizenſhip is in heaven*, being but a *ſtranger upon earth*, converſes among the *men of the world*, though in matters indifferent, there is oft-times required by prudence as much of compliance, as is allowed by innocence; yet, when there happens an occaſion, wherein he cannot comply with the depraved cuſtoms of thoſe, among whom he

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lives, without diſobeying him, for whom he lives, and whoſe ſervant he is, or doing ſomething, that would derogate from the dignity of a perſon related to ſuch a maſter, he will then leſs conſider, what may be thought of him by a multitude, than what account he is to render to him, who has forbidden men *to follow a multitude to do evil.* And as he knows, that his reward would be much leſs than he reckons upon, if it were a thing to be received on earth, not in heaven; ſo, how ſtrange and unfaſhionable ſoever his conformity to the orders of his own ſovereign may appear, he chuſes rather to diſpleaſe men than God, and acts, as both *ſeeing*, and being ſeen by, *him that is inviſible.*

A continuation of the DISCOURSE.

AND this ought to be more eaſy to him, than their ſingularity is to the Ruſſians, I have been mentioning; for whereas theſe, if they be knowing, and impartial, refuſe our modes and rites, not becauſe they are worſe, but only becauſe they are other than thoſe of their country; he refuſes to conform to the forbidden faſhions of this world, not for their being different from thoſe of the kingdom he belongs to, but for their being bad, and condemned by him, that cannot err: whereas, of the oppoſite practices, the ſame infallible judge pronounces, by the mouth of a perſon by him inſpired, that *theſe are the good things, and the profitable unto men.* And whereas theſe ſtrangers ſee nothing in this magnificent aſſembly, whoſe faſhions they decline, fit to be deſpiſed, but ſee ſome perſons in it, to whom they pay a great reſpect, and who deſerve it upon another account, than that of their wearing crowns; thoſe, that are loyal to virtue, have cauſe to look upon thoſe they refuſe to be like, with a noble, and juſt indignation, as perſons that have degraded themſelves, and by unworthy practices blemiſhed, and almoſt forfeited, the dignity of their nature, and the nobler title of Chriſtians. And, whereas theſe Muſcovites are morally certain, that we ſhall never prefer their faſhions to our own, the Chriſtian has as great an aſſurance, that thoſe, whoſe practices he diſſents from, will one day repent, that their's diſſented from his, and will wiſh they had imitated what they now ſeem to ſcorn. And however, when he ſhall come to the celeſtial city he belongs to, he will be in no danger to be derided for the ſake of piety, ſince thoſe, that deride piety, will not be admitted there. And as theſe Ruſſians could not take a better way, than that of not ſneaking, to avoid the having their rites and perſons undervalued; ſo for a Chriſtian not to bluſh at his unfaſhionableſt practices, ſeems the hopefulleſt way to keep them and him from being ſcorned, eſpecially with thoſe, who having themſelves no quality better than confidence, value it moſt in others. And ſure it were a very unlikely way, to keep others from deſpiſing the cuſtoms of the heavenly *Jeruſalem*, for him, that belongs to it, to appear aſhamed of them himſelf. Nor have pious perſons cauſe to be out of countenance, at the ſingularity even of a ſtrictly virtuous deportment, ſince, being (as the Scripture tells us ſuch men in general are) *fellow-citizens with* the ſaints and domeſticks of God, they cannot juſtly be blamed, if they aſpire to be as like as they can here, to thoſe, whom they deſire and hope to be perfectly like hereafter. And if the angels (as the Scripture in ſeveral places ſeems to intimate) are witneſſes of our actions, the ſmalleſt number of unfaſhionable good men may, upon that ſcore, ſay to one another, as the Prophet did to his ſervant, upon the account of the heavenly hoſt that ſurrounded him, *Fear not, for they that be with us are more than they that be with them.* And the approbation of theſe illuminated, happy, and glorious ſpirits, is ſure more conſiderable than that of mortal, and, which is worſe, of ſenſual men, whether we conſider their number, or their judgments. And however, the day will come, when thoſe, that deſpiſe their ſingularity, will envy his happineſs; one welcoming ſmile from Chriſt will make him amends for all the ſcornful ſmiles of ſinful men; and the ſentence of abſolution, and bliſs, ſolemnly pronounced before God, angels, and men, will not only recompenſe him for the world's diſ-eſteem, but ſhew, that he did not deſerve it.

Tit. iii. 8.

2 Kings vi. 16.

REFLECTION VI.

Upon the ſight of roſes and tulips growing near one another.

IT is ſo uncommon a thing to ſee tulips laſt till roſes come to be blown, that the ſeeing them in this garden grow together, as it deſerves my notice, ſo methinks it ſhould ſuggeſt to me ſome reflection or other on it. And perhaps it may not be an improper one, to compare the difference betwixt theſe two kinds of flowers, to the diſparity, which I have often obſerved, betwixt the fates of thoſe young ladies, that are only very handſome, and thoſe that have a leſs degree of beauty recompenſed by the acceſſion of wit, diſcretion, and virtue: for tulips, whilſt they are freſh, do indeed by the luſtre, and vividneſs, of their colours, more delight the eye than roſes; but then they do not alone quickly fade, but as ſoon as they have loſt that freſhneſs, and gaudineſs, that ſolely endeared them, they degenerate into things not only undeſirable, but diſtaſteful; whereas roſes, beſides the moderate beauty they diſcloſe to the eye, (which is ſufficient to pleaſe, though not to charm it) do not only keep their colour longer than tulips, but when that decays, retain a perfumed odour, and divers uſeful qualities, and virtues, that ſurvive the ſpring, and recommend them all the year. Thus thoſe unadviſed young ladies, that becauſe nature has given them beauty enough, deſpiſe all other qualities, and even that regular diet, which is ordinarily requiſite to make beauty it ſelf laſting, not only are wont to decay betimes, but as ſoon as they have loſt that youthful freſhneſs, that alone endeared them, quickly paſs from being objects of wonder, and love, to be ſo of pity, if not of ſcorn; whereas thoſe, that were as ſollicitous to enrich their minds, as to adorn their faces,

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faces, may not only with a mediocrity of beauty be very desirable, whilst that lasts, but notwithstanding the recess of that, and youth, may, by the fragrancy of their reputation, and those virtues and ornaments of the mind, that time does but improve, be always sufficiently endeared to those, that have merit enough to discern and value such excellencies; and whose esteem and friendship is alone worth their being concerned for. In a word, they prove the happiest, as well as they are the wisest, ladies, that whilst they possess the desirable qualities, that youth is wont to give, neglect not the acquist of those, that age cannot take away.

REFLECTION VII.

* *An unpublished piece of the author's.*

(Taken out of the 2d book of the * martyrdom of *Theodora*, and turned into an Occasional Meditation.)

Upon the sight of a branch of coral among a great prince's collection of curiosities.

THE present and future condition of a Christian, especially of a martyr, is not ill represented by what we take notice of in coral; for whilst that shrub yet lives, and remains fastened to its native earth or soil, it grows in an obscure region of the world, and is perpetually surrounded, and over-flown, by the brackish and unpleasant waters of the sea, and oftentimes exposed to the irregular agitations of its waves. Besides, the substance of this plant (as those that should know inform us) is but soft and tender under water, and its colour but sad and unlively: nor is it, like the tulip or the rose-bush, adorned with any pleasant verdure, and much less does it flourish with gaudy colours. And whilst it remains under water, the excellency of it does so little disclose it self, that men sail over it without suspecting or dreaming they have any thing of precious under their feet; and by the fishes, in whose region, or rather element it grows, it is passed by wholly unregarded: but when this unheeded coral comes to be torn off from its root, and plucked out of his soil, and so is killed in the capacity of a plant, it then exchanges the dark and unquiet place it was confined to, for a more elevated and lightsome region; and instead of sharing the fate of common shrubs and flowers, first to degenerate into fading colours and offensive smells, and then to perish, either by rottenness or fire, our coral, by the violence offered to it, acquires a delightful redness, together with a solidity and a durableness, that makes it a thing so lovely and immortal, that it serves for an ornament for the cabinets of the curious; and what stupid fishes do not at all regard, those nobler creatures, men, do so highly prize, that oftentimes it finds place even among the rarities of princes.

THUS, a true Christian, whilst he is yet confined to the region of the animal life, lives oftentimes in an obscure and low condition, and far from that prosperous state, wherein the world's favourites are wont to flourish: he is almost perpetually exposed to pressures and afflictions; and either most men consider him not at all, or those, that look at his outside only, are apt to despise him, because it is so homely. And he is not only in such a (seemingly forlorn) condition, as made the Psalmist complain of himself, that *all the waves passed over him*; but (like those plants of coral, that, not growing so near the shore, are constantly covered with water, as well as sometimes disordered by storms) the calamities, that do, as it were, overwhelm him, are never altogether removed, even in the intervals of those tempestuous fits, which increase his distresses: but when the violence of sickness, or the fury of a persecutor shall have taken away his life, he must be then translated into a higher and happier region, afflictions and distresses will be all left behind. And when the sensual idolizers of their bodies shall be condemned to have those as loathsome as were their minds, and as restless as their guilty consciences, his body will obtain new and glorious qualities like that of his redeemer, and his soul shall find no less happy a transfiguration; the *mortal part will be swallowed up of life, that perfection, which is but in part, shall be done away.* And these newly acquired excellencies of the whole man will never after vanish or decay. And he, that lived unregarded by the stupid inhabitants of the earth, shall be joyfully welcomed into the blest society of celestial spirits; and, what is infinitely more, be graciously welcomed and dignified by the Son of God himself. Men should not therefore, by a Christian's present state, take their measures of his future fate, but rather should remember, that he, who said of such, *They shall be mine in the day when I make up my *special treasures*, is one, whose estimate of persons and conditions we may safely rely upon, since he is able to make any of them infallibly such as he pleases to pronounce them, and consequently we may look upon the constant Christian's differing condition, with his eyes, that said, *We are now the sons of God, and it does (not indeed) yet appear what we shall be, but we know, that when he shall appear, we shall be like HIM*; who would be like himself alone, did not his goodness vouchsafe to exalt those that love him, to a likeness, which makes them very unlike the gloriousest things we here admire, by incomparably transcending them.

2 Cor. v. 4. τὸ θνητὸν.

Mal. iii. 17. * *Segullah.*

2 Joh. iii. 2.

REFLECTION VIII.

Upon the sight of the effects of a burning-glass.

IT is a fault incident to many good men, to be too much indisposed to entertain the precepts of virtue, as such excellent things deserve, in case, those, that teach them, do not practise them. There are too many, that do not think themselves obliged to take even the wholesomest advice from those, whom they see more careful to give it others, than to follow it themselves. And some of them are so nice, that they will scarce read a book of devotion, unless it come, like that St. *John* eat in the *Apocalypse*, from the hand of an angel. But for my part, though I hope I both value and desire

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ſire religious preachers as much as the reſt of my brethren, yet I think it would be much to the injury of Scripture and of reaſon, if we ſhould ſuffer the perſonal faults of men to keep them from doing that good, their nature fits them for. The etymology of the goſpel importing its being welcome news, it is pity, that any one that teaches it ſhould not have a title to the character *David* gave *Ahimaaz*, of whom he ſaid, that *he is a good man, and brings good tidings*. But my deſirouſneſs of piety in a preacher is more for others ſake than mine. For I know not why truth, which is an intellectual thing, ſhould loſe its nature by any moral vicioúſneſs in the propoſer. I know there is ſomething extraordinary in the caſe of *Noah*, who awoke from his wine, and immediately propheſied, and yet the event verified his predictions. Our Saviour inſtructing his diſciples about the Scribes and Phariſees, who ſat in *Moſes*'s chair, at the ſame time commands them to conform to their doctrine, when he forbids them to imitate their example. The wiſe-men did not the leſs find Chriſt at *Bethlehem*, though the prieſts and Phariſees ſent them without accompanying them thither. And the Aſſyrian general was cured of his leproſy by following the Prophet's preſcription conveyed him by that *Gehazi*, who, by his unworthy carriage in that buſineſs, tranſplanted (if I may ſo ſpeak) that foul diſeaſe into himſelf and his poſterity. I will therefore conſider ſermons more than preachers: for as in a burning-glaſs, though the ſun-beams do but illuſtrate, not heat, it in their paſſage, they may yet, by its aſſiſtance, kindle ſubjects, that are more diſpoſed to receive their action: ſo thoſe very truths and notions of a learned preacher, which do but enlighten him, may inflame his hearers, and kindle in their hearts the love of God. And as if a perfume be ſet on fire by the beams projected through a burning-glaſs (which they do not ſo much as warm in their paſſage) the ſcent is no leſs odoriferous and grateful, than if it had been produced by an actually burning coal. So neither is that devotion, which is kindled by the eloquence of an indevout preacher, any whit the leſs acceptable to God for their not being themſelves affected with the zeal they beget in others. And what the book of *Kings* relates of *Eliſha*'s bones, contains a far greater miracle in the hiſtorical, than in the allegorical ſenſe, in which it is no ſuch wonder to ſee a man raiſed to life by a dead prophet.

REFLECTION IX.

Upon the finding a horſe-ſhoe in the high-way.

THE common people of this country have a tradition, that it is a lucky thing to find a horſe-ſhoe. And though it was to make my ſelf merry with this fond conceit of the ſuperſtitious vulgar, I ſtooped to take this up; yet now I obſerve in it a circumſtance, that may, for aught I know, ſomewhat juſtify the tradition. For I take notice, that though horſe-ſhoes are by travelling worn out, yet if they had a ſenſe of their own condition, it might afford them ſome conſolation in it, that the ſame journies, that waſte them, make them both uſeful and bright. Whereas, though the horſe-ſhoe I have taken up have not been conſumed upon the account of travelling, it has been eaten up by ruſt, which waſtes it as well as attrition would have done, but does not give it the luſtre it would have received from that. I meet with many, who, very unmindful, that he, who was juſtly ſtyled the wiſeman, whoſe counſel it was, that *what ever our hand finds to do, we ſhould do it with all our might, &c.* make it the main buſineſs of their life merely to lengthen it, that are far more ſolicitous to live long, than well, and would not undergo the leaſt labour, or endure the leaſt hardſhip, to do the greateſt good, but had rather loſe an hundred opportunities of ſerving God, or obliging men, than an entertainment, or an hour's ſleep, and all this under the pretence of minding their health, and complying with the dictates of ſelf-preſervation. But I have often obſerved too, that even theſe jolly people, that ſeldom have a ſerious thought, but how to avoid ſerious imployments, may, by making their whole lives a ſucceſſion of divertiſements, or rather a conſtant diverſion from the true end of them, make their lives indeed thereby uſeleſs, but not at all immortal. And truly, fevers, pleuriſies, and other acute diſeaſes, that are home-bred, beſides thoſe numerous fatal ones, that are caught by contagion, and a multitude of caſualties, do cut off ſo many before they reach old age, in compariſon of thoſe, that the diligence, and induſtry, impoſed by religion, or curioſity, deſtroy, that I think ſo great a fear of uſing the body for the intereſts of the ſoul, and of him to whom we owe both, does very little become his diſciples, who ſaid, that it was *his meat to do the will of God that ſent him, and to accompliſh his work*. The trouble of thirſting, and ſweating, and undreſſing, would to an ingenious man be but juſt recompenſed by the bare pleaſures of eating, and drinking, and ſleeping: to confine an honeſt and inquiſitive perſon from thoſe, which he looks upon as the almoſt only manly employments, the exerciſe of virtue, and the purſuit of knowledge, by telling him, that ſuch a forbearance may protract his life, is to promiſe a thing upon a condition, that deſtroys the end and uſe of it; and he will look upon it, as if you ſhould offer him a horſe, provided he will not ride him, or a perſpective-glaſs, upon condition he ſhall not draw it out, for fear the air ſhould, as it ſometimes does, impair the glaſſes. A heaven-born ſoul would ſcarce think it worth while to ſtay here below, if its work muſt be, not to employ the body, but to tend it. Thoſe, that are ſo unreaſonably afraid to ſpend their ſpirits, are in ſome regards leſs excuſable than miſers themſelves; for though both hoard up things, that cannot be better injoyed, than by being parted, with, the chief uſes for which they were intruſted with them; yet in this, thoſe I blame are more cenſurable, than the covetous themſelves, ſince theſe, by their niggardlineſs, can avoid ſpending their money, but the others, by

John iv. 34.

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by their lazineſs, cannot avoid the conſumption of their time. I know a man may be prodigal of himſelf, as well as his eſtate; and that both thoſe profuſions are faults, and therefore fit to be declined. But if I could not ſhun both the extremes, certainly, ſince we all muſt die, and the queſtion is not, whether or no we will live for ever, (for the moſt, that can be hoped for, is not to be privileged from death, but only to be longer reprieved) but whether we will rather endeavour to lead a life, mean, and unprofitable, a few more days, or a glorious life, for a ſomewhat leſs number of them? I ſhould rather chuſe to ſpend my life quickly, than uſeleſsly; for he, that lays out himſelf for eternity, if he loſe any portion of his time upon that account, is the ſooner put into poſſeſſion of an inexhauſtible ſtock of it; whereas thoſe, who, that they may live long, meanly forgo the ends of living, and ſeek, by lazineſs, to protract an inſignificant ſtay on earth, would, ſhould they reach their aim, add rather to their years than to their life.

REFLECTION X.

At the Hague.

Upon the ſhop of an ugly painter rarely well ſtored with pictures of very handſome ladies.

GENORIO, LINDAMOR, EUSEBIUS.

GENOR. HERE is a deceitful ſhop of beauty, where many, that come but to wonder, meet with love, and even when they buy not what they like, pay their hearts for it; the ſhop being ſo well furniſhed, that beauty ſeems here to have aſſumed all the variety of features, and complexions, ſhe can be dreſſed in, and ſo exquiſitely to have fitted all gazers with proportionate and attractive objects, that nothing but an abſolute incapability of love is here able to protect them from that paſſion, which, not to reſent among ſo many inſpiring wonders, were one. If in theſe faces, the originals equal the tranſcripts; if art have not flattered nature, and attempted more to inſtruct than imitate her; and if the painter have not elected, rather to have his pieces liked, than like, here are apologies for love, that can procure it, not only pardons, but proſelytes. I muſt (in that caſe) add, that there are more ſuns than one, whoſe brightneſs, even by reflection, can dazzle; here are princeſſes more illuſtrious for the blood, that lightens in their cheeks, than for that, which runs in their veins, and who, like victorious monarchs, can conquer at a diſtance, and captivate by proxy.

EUSEB. I fear, *Genorio*, that you are ſo tranſported with your text, that you will quite forget (if ever you intended it) to make a homily upon it: for you talk at ſuch a rate, as if you were about to loſe, to the pictures of ladies, the liberty, your friend Mr. *Boyle* would be thought to have ever defended againſt their originals, and fancied, that it might add to the other reſemblances you ſo admire betwixt them, if both of them were made enemies to ſeriouſneſs.

LIND. I preſume, *Genorio* will willingly allow me to ſerve him at this turn; for whether or no he meant us a reflection, ſome charms or other he has met with in theſe pictures, ſeem to have ſo arreſted his thoughts, as well as his looks, that we ſhall not have them haſtily delivered from ſo pleaſing a captivity; and the knowledge I alone, of us three, have of the drawer of theſe pictures, ſupplies me with a circumſtance, without which, I ſhould not, when *Euſebius* is by, offer at an occaſional meditation. But upon this advantage, I ſhall venture to tell you, that the thing I was conſidering, was, that though the limner have drawn ſome pieces, as handſome as lovers think, or wiſh their miſtreſſes, and ſome (as they tell me) ſo like, that an actual confrontation of the artiſt's works, and nature's, would ſcarce diſtinguiſh them, (ſince the former would appear to differ from the later, but in that ſilence, which the later's admiration, to ſee themſelves ſo perfectly repreſented, would impoſe) yet is the painter himſelf ſo deformed a creature, that he might draw a lovelier face even than any here, by drawing one perfectly unlike his own. Alas! this diſcloſes the difference there may be betwixt the being able to write fine characters of virtue, and the poſſeſſing of it. How ridiculous ſhould I eſteem this limner, if with all this uglineſs, he ſhould eſteem himſelf handſome, becauſe his pencil can draw faces that are ſo! As abſurd were it for us, to grow proud of our devout compoſures, and fancy piety ours, becauſe our diſcourſes can poſſibly inamour others of it. The devil ſometimes does unmoleſtedly ſuffer us to write well, if he can but perſuade us we need do no more, and that good pens may diſpenſe us from good actions. Our paper-wars againſt vices are oftentimes like *Alexander*'s againſt the neighbouring nations, not out of hatred, but glory, not to extirpate, but to conquer them, and manifeſt to the world the ſufficiency of our parts, by a victory, after which we often treat the vanquiſhed enemy with greater courteſy, than thoſe, whoſe quarrel we undertook. Diſcourſes againſt vices may be as well indited by vanity, as by zeal, and meant to expreſs wit, not perſuade piety. And if (as it chanceth but too frequently) we grow proud of them, we do, like witches turning exorciſts, only comply with Satan to caſt out the devil.

EUSEB. To ſecond your pious reflection, *Lindamor*, with ſome thoughts ſuitable to my profeſſion, I will add, that in the caſe you put, it happens to us as it once did to *Gideon*, who, of the ſpoils of God and *Iſrael*'s conquered enemies, made an idol, which proved, in the end, his, and his houſe's ſnare. It was a moſt inſtructive check, and divine admonition, that our Saviour gave his Apoſtles, when, in the account they brought him of their embaſſy, they joyfully related their excerciſed power, of diſpoſſeſſing devils; *notwithſtanding* (anſwered Chriſt) *in this rejoice not, that ſpirits are ſubject to you, but rather rejoice, that your names are written in heaven.* In effect, though *Judas* were one of the perſons, inveſted with this miraculous Judg. viii. 24, 25, 26, &c.

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raculous power of casting devils out of others, yet we read, that *Satan* afterwards *entered into* Judas, *and that it had been good for him, that he had never been born.* And though, as *Solomon* tell us, *he that winneth souls, is wise,* yet it is he only, that shall *do,* as well as *teach,* the
Mat.v. 19. commandments, *that shall be called great in the kingdom of heaven.* And the judge himself informing us, that, at the world's last day, many
Mat. vii. 22. 23. will plead their *having in his name not only prophesied or preached, but cast out devils,* and shall yet be disclaimed by him, sufficiently intimates, that it is as possible, as unavailable, *to do many wonderful works* (for religion) and to be *workers of iniquity.* The true Christian should, *Lindamor,* be willing to impart any useful discoveries, that God shall please to vouchsafe him; but he will ever consider the takingest notions he can frame of virtue, more as engagements to it, than arguments of it: and since there is not any thing, in which charity ought more to begin at home, than in devout instructions, he will endeavour to make himself as much piety's votary, as advocate; to imitate those truly wisemen, that, as they informed those of *Jerusalem* of the star they had seen in the east, did themselves follow it, till it brought
Luke vi. 45. them unto Christ; to entitle himself to that of our Saviour, *a good man out of the good treasure of his heart, brings forth good things:* and (finally) to take his celebrations of virtue from his experience, not his fancy; as nurses first feed themselves, to nourish their sucking infants, to whom they give no meat, which they have not in their own breasts first digested into milk, lest (like the carpenters, that toiled to
1 Cor. ix. 27. build the ark to save *Noah* from the deluge, themselves perished in,) *when he has preached to others, he himself should prove a cast-away.*

A continuation of the discourse.

GENOR. SURE, gentlemen, it is a happy thing to be able to convert the meanest things to the noblest uses, and make whatever one pleases subservient to piety, by skilfully imploying even slight and unpromising occasions, to represent her, with the advantages of a varied and surprizing dress, whereby you may procure that virtue lovers, and your selves friends: for her votaries are so ingenuous and disinterested in their amours, that they have as well a kindness for their rivals, as their mistress.

LIND. I will not deny, but that there may be persons so inflamed with heavenly love, that their devotion is able, like the last fire, that is to refine or destroy the world, to turn all things into fuel for its victorious flames; and who, when they are once ingaged in meditation, can make their pious thoughts excite themselves and flame up higher, and higher, without the assistance of other incentives, than what their own fervency procures them; as it is observed, that when the fire has seized upon a town, by how small a spark soever it have been kindled, if the flame come to be very great, though the air be very calm, the fire it self will produce a wind, that without the help of bellows shall strongly blow it, and make it blaze the more, and aspire towards heaven. But, *Genorio,* whenever (for I answer but for my self) I shall meet with any such happy contemplators, I shall have the justice to be one of their admirers, without having the vanity to pretend to be one of their number.

EUSEB. And I, for my part, shall tell you, *Genorio,* that though there may be divers charitable persons, besides your self, that by the expressions it becomes me to use in some of my meditations, and other compositures of the like nature, may be apt to fancy that I am my self as devout as I endeavour to make my readers, yet you must not imagine that my mind, like one of those writings, has no other thoughts than religious, or at least moral ones; for those may be the productions, not of a constant frame of mind, but of occasional fits of devotion: and you may read a greater number of such reflections in an hour than, perhaps, I have made in a month, not to say in a year. And I must ingenuously confess to you, that I think it more easy to make ten good sermons than to practise one, and to declaim against all sins than to relinquish any: there goes much less self-denial to conform to the precepts of *Cicero,* than to those of Christ; and I find it so much less difficult to excite other men's passions, than to command my own, that if you will not suffer your charity too much to injure your judgment, you must look upon the devouter passages you may have met with among my compositures, as expressions of what I aim at, rather than of what I practise.

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An Account of a very odd monſtrous Calf; *printed firſt in the* Philoſophical Tranſactions, N° I. p. 10. Anno 1665.

BY the ſame noble perſon [Mr. *Boyle*] was lately communicated to the Royal Society an account of a very odd monſtrous birth, produced at *Limmington* in *Hampſhire*, where a butcher, having cauſed a cow (which caſt her calf the year before) to be covered, that ſhe might the ſooner be fatted, killed her when fat, and opening the womb, which he found heavy to admiration, ſaw in it a calf, which had begun to have hair, whoſe hinder legs had no joints, and whoſe tongue was, *Cerberus*-like, triple, to each ſide of his mouth one, and one in the midſt: between the fore-legs and the hinder-legs was a great ſtone, on which the calf rid: the ſternum, or that part of the breaſt, where the ribs lie, was alſo perfect ſtone; and the ſtone, on which it rid, weighed twenty pounds and a half: the outſide of the ſtone was of greeniſh colour, but ſome ſmall parts being broken off, it appeared a perfect free ſtone. The ſtone, according to the letter of Mr. *David Thomas*. who ſent this account to Mr. *Boyle*, is with Doctor *Haughteyn* of *Salisbury*, to whom he alſo referred for further information.

An Obſervation imparted to the noble Mr. Boyle, *by Mr.* David Thomas, *touching ſome particulars further conſiderable in the* Monſter, *mentioned above*; *printed firſt in the* Philoſophical Tranſactions, N° II. p. 20.

UPON the ſtricteſt inquiry, I find by one, that ſaw the monſtrous calf and ſtone, within four hours after it was cut out of the cow's belly, that the breaſt of the calf was not ſtony (as I wrote) but that the ſkin of the breaſt and between the legs of the neck (which parts lay on the ſmaller end of the ſtone) was very much thicker, than on any other part; and that the feet of the calf were ſo parted, as to be like the claws of a dog. The ſtone I have ſince ſeen; it is bigger at one end than the other; of no plain ſuperficies, but full of little cavities. The ſtone, when broken, is full of ſmall pebble ſtones of an oval figure: its colour is grey like free-ſtone, but intermixt with veins of yellow and black. A part of it I have begged of Dr *Haughteyn* for you, which I have ſent to *Oxford*, whither a more exact account will be conveyed by the ſame perſon.

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NEW

EXPERIMENTS

AND

OBSERVATIONS

TOUCHING

COLD,

OR,

An Experimental Hiſtory of COLD begun.

To which are added,

An EXAMEN of *ANTIPERISTASIS*, and an EXAMEN of Mr. *HOBBES*'s Doctrine about COLD.

Whereunto is annexed an *Account of Freezing*, brought into the ROYAL SOCIETY by the learned Dr. *C. MERRET*, a Fellow of it.

Together with an *APPENDIX*, containing ſome promiſcuous *Experiments* and *Obſervations* relating to the precedent Hiſtory of COLD.

Non fingendum, aut excogitandum, ſed inveniendum, quid natura faciat, aut ferat. BACON.

The Publiſher to the Reader.

A GREAT progreſs having been made at the preſs in the ſecond edition of the *Hiſtory of Cold*, before the author was acquainted with it, he did not think fit to make any alteration of the former edition, but left it to come forth this year, juſt as it was printed ſeventeen years ago, *viz.* in the year 1665.

FOR the ſame reaſon, the author declined making any alteration in the introductory preface; whoſe prolixity ſeemed very excuſable, becauſe it was not barely a preface to the particular book, whereunto it was prefixed, but (as the title was deſigned to intimate) contained divers conſiderations introductory to the *Hiſtory of Cold* in general, and ſuperadded divers experiments and obſervations to thoſe, that were delivered in the hiſtory itſelf.

THE author thinks he may juſtly hope, that equitable readers will not look upon the thermometrical diſcourſes, that are premiſed to the *Hiſtory of Cold*, as unfit to appear again with it; though ſome of the particulars, that are there delivered as paradoxal, are now acknowledged for truths by moſt of the Virtuoſi; and others, that are propoſed as new obſervations and practices, are, at preſent, come into common uſe among the curious. For the ancient date of theſe diſcourſes will eaſily make it appear, that the things they mainly conſiſted of, were then novelties. And he hopes it will not diſparage them among the equitable readers, that many have ſince thought fit to embrace the opinions, and make uſe of the practices, there propoſed.

BUT it will be now expected, that ſomewhat ſhould be ſaid about the following Appendix, wherein the author is very ſenſible, that he ſtands more in need of the reader's equity and favour. For, not being ſollicited to make a ſecond edition, (after men's curioſity and the fire of *London* had diſperſed or deſtroyed the firſt) till want of leiſure made him unwilling, and want of health almoſt unable, to reviſe and proſecute that work; he threw aſide the particulars he intended to add among other looſe papers, where for many years they lay neglected, and probably there were divers of them loſt: ſo that when the ſtationer and ſeveral other perſons were preſſing to have a new edition of the former *Hiſtory of Cold*, and gave the author notice, that a good part of it was already printed off, and waited for ſome additions, that they earneſtly deſired, he had much ado to retrieve any conſiderable

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ſiderable number of notes; moſt of which too being occaſionally written, when he could not get one exemplar to collate them with, (the ſtationer himſelf having not ſo much as one book left) it was almoſt neceſſary, that many of them ſhould be ſo written, as to be eaſily and ſmoothly joined to the titles of the formerly publiſhed hiſtory. So that the author (who at that time was much indiſpoſed) having neither health nor leiſure to put this chaos of looſe memoirs into ſome order, deſired a learned friend to take upon him the trouble of doing it for him: yet it was not poſſible, for all that ingenious perſon's care and diligence, to give a good method and ſmooth connexion to ſo confuſed an heap of particulars; all that the difficulty of the attempt permitted him to do, being to refer the particulars, as near as might be, to the reſpective titles they ſeemed moſt to belong to.

IT remains, that the reader be told, whence the materials have been taken, whereof the following Appendix doth conſiſt: ſome few of them have been drawn out of printed books, becauſe cold (in itſelf, a ſubject barren enough) has been left ſo uncultivated by claſſick authors, that, according to our judicious *Verulam*'s advice, it was not thought fit to caſt away any credibly-related matter of fact, that might add to the hiſtory of it. But the greater number by far of the following particulars was taken from the relations of navigators and travellers, whom the author had the curioſity to conſult about the phænomena of cold, they had met with. And for the better gaining of ſuch informations, he became an adventurer in that, which is commonly called the *Company of Hudſon*'s *Bay*; to which thoſe that are from time to time ſent from *London*, do, either in their voyages thither and back again, or in their ſtay in that frozen country, not unfrequently meet with conſiderable, though unwelcome effects of cold. But two perſons there are above the reſt, from whoſe anſwers the author drew the conſiderableſt part of the following Appendix. One was an ingenious Engliſh phyſician, dead many years ſince, that was archiater to the then Ruſſian emperor; for whom our author having furniſhed this phyſician with ſome pleaſing, and yet effectual, chymical medicines, that were very well liked, and nobly rewarded by the Czar, the author deſired, as his recompenſe, to have ſome obſervations about cold (whereof he ſent a liſt) made in *Ruſſia*, and eſpecially at the city of *Moſcow*, where the phyſician, attending his maſter, reſided. The anſwers to Mr. *Boyle*'s queries were, by misfortune, not ſent by themſelves, but in ſeveral letters intermingled with ſo many other paſſages, relating to the Ruſſian monarch's government, religion, *&c.* that to put them in the writer's own words (which was thought the faireſt and ſureſt way to prevent miſtakes) ſome of them muſt be diſmembered from the context, and ſo muſt appear as torn and incoherent rags, and conſequently to the great diſadvantage of the papers they are made parts of. The other principal informations to be met with in this Appendix, the author received in divers conferences he procured with an ancient ſea-captain, who was looked upon as the greateſt navigator into the Northern ſeas, that has been known; upon which account his majeſty himſelf had the curioſity to ſend for him, and diſcourſe with him. This luſty old man had made above thirty ſeveral voyages into the frigid zone; and being then (as he ſtill is, if he be yet alive) in the ſervice of the company of *Hudſon*'s *Bay*, was, upon that account, the more willing, and the more free, to make anſwer to the author's queſtions, even when it required the diſcovery of his moſt ſecret obſervations. And, that this preface may not be altogether uſeleſs to the deſign of the hiſtory it belongs to, I ſhall add, on this occaſion, that the author having been viſited by the principal perſon, that ventured to winter in *Hudſon*'s *Bay* (where the ingenious captain *James*, often mentioned in the foregoing hiſtory, found it almoſt, if not quite, as rigorouſly cold, as the Hollanders found *Nova Zembla*) he was particularly inquiſitive to learn of this perſon, how he was able to ſupport the extreme rigours of the cold all the winter long: to which inquiry the navigator anſwered, that the cold was ſcarce ſufferable the firſt year he ſettled there; but that aftewards they had found an expedient to make their wintering not only tolerable, but comfortable enough. And being preſſed to name this expedient, he ingenuouſly confeſſed it to be this; that they dug ſo deep into the earth, where they thought fit to erect their wintering-houſe, that about one half of their manſion, and that part, wherein they dwelt themſelves, was built under ground; by which means the cold air could not laterally pierce into it, ſo that they ſlept warm enough, and in the day-time could keep themſelves from exceſſive cold, as long as they continued in that ſubterranean part of their houſe.

THE following papers having been ſent away to the preſs, without being reviewed by the author after the particulars, that compoſe this Appendix, were ranged in the order they now appear in; when afterwards he received them all at once as they now ſtand printed, he found (not without being troubled at it) that to comply with the deſign of referring particulars to their proper heads, ſome paſſages in this new model of them had loſt their dependencies, or the connexions they had in the papers whence they were taken. As for inſtance, the governour of *Smolenſco*, upon the borders of *Poland* and *Ruſſia*, though not here called by his own name, is mentioned as a perſon formerly nominated; which might well be done in the papers, whence this particular was extracted, becauſe he had in them, before that, been quoted by the name of Lieutenant-General *Drummond*. Nor is this, (it is feared) the only paſſage, wherein the almoſt neceſſary diſlocation of particulars, that before had a manifeſt connexion, may need the reader's pardon, which is therefore begged by the author; who yet hopes, that theſe paſſages will not be found numerous, and that an attentive reader will, by circumſtances, eaſily enough diſcern what things are his own, and thoſe comparatively few, that might have been

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more expreſly delivered, as received from others. This inconvenience was not eſpied, till it was too late to prevent it.

SOME few particulars in the following Appendix may perhaps be found coincident, as to the main, with ſome paſſages of the book it is annexed to, and yet differing in ſome circumſtances. But theſe the author thought it candid not to ſuppreſs, becauſe in hiſtorical matters truth is the thing, that is to be principally regarded: beſides, that in theſe points, wherein the relations of the hiſtory and of the Appendix agree, they will mutually confirm each other, (which in matters, whereof few trials or obſervations are yet extant, is a thing of no ſmall moment;) and thoſe circumſtances, that may ſuggeſt limitations or cautions, may be of good uſe in the *Philoſophick Hiſtory of Cold*, and engage the curious to make a farther ſearch by heedful and repeated trials.

THE author had divers other papers, that might have enriched the preſent Appendix, if the confuſion, that was occaſioned among his manuſcripts, by a ſudden fire, that obliged him very haſtily to remove them after midnight, had not ſuppreſſed them, (and which he hath elſewhere complained of, as very prejudicial to him in reference to other tracts) at leaſt till another opportunity. But without the proſpect of a larger appendix, the printer wanted not encouragement to preſs for a ſecond edition, by the favourable reception, that was given to the firſt by divers learned men, not only at home but abroad: where Monſieur *Du Hamel*, famous for many curious and elaborate pieces, in one of his learned treatiſes, gives this character of the foregoing hiſtory: *Cum anno ſuperiore inciderim in librum de frigoris hiſtoria, ab illuſtri & doctiſſimo viro D.* Boyle *compoſitum, quo argumentum, à philoſophis penè intactum, tam diligenter & eruditè pertractavit, ut vix quicquam accuratius ſperari poſſit. Du Hamel Corp. Aff. Cap. de Frigore.* And ſince him an ingenious doctor of phyſick, (that in a cold climate has written, though not copiouſly, yet learnedly and *ex profeſſo*, of *cold*) ſpeaks thus of our author and of his hiſtory: *Agmen hoc eruditum* (having ſpoken before of the chief authors, that have written about *cold*) *claudat Dominus* Boyle, *delicium & ornamentum noſtri temporis, cui jam nunc omnem noſtram attentionem renovare æquum eſt. Non enim aliam ob cauſam hoc loco ultimo eum amplectendum nobis ſervavi, quàm ut veluti per compendium, liberiori tamen paulò excurſione factâ, & ſepoſito nonnihil capitum præcedentium ordine, tum ea, quæ jam partim allata fuere, tum quæ dicenda adhuc reſtant, ſine tædio & concinnâ brevitate, ejus quaſi ductu, quem toto hoc lubrico & glaciali itinere ducem mihi propoſui, examini ulteriori ſubjicerem.* Conradi Diſſertat. Medico-phyſ. de Frigoris Natura & Effectibus, *pag.* 51.

THESE juſt elogies of our honourable author (to omit many others) are here inſerted, not to grate on his modeſty by the repetition of his own (tho' merited) praiſe, but as incitements to the ſtudious to peruſe his philoſophy, with the principles thereof, contained in this and his other tracts, (which in many things differ from thoſe of the *Peripatus*, the *Academia*, and the *Stoa* too) in regard they have already paſſed the teſt of the learned both at home, and alſo beyond the ſeas. For though, as an ingenious writer ſpeaks in another caſe, little heed is to be given to the gale of a private man's fancy, yet it is conſiderable, when the wind blows from all quarters. The univerſal approbation, which the labours of our author have met with, requires an high veneration for, and medullary ſearch into, his writings. It was the ſaying of an ancient rhetor, in reference to oratory, *Ille ſe multùm profeciſſe ſciat, cui* Cicero *valde placuerit*; which may be applied with as much veracity to Mr. *Boyle*, whoſe philoſophical lucubrations about the ſubjects he is pleaſed to ventilate and diſcuſs, are the top of their kind. Therein the *Initiati* may find great encouragement for their progreſſion, and alſo thoſe, who are more experienced, and ſit but one form below the *Adepti*, may count it no diſparagement to learn of him, whoſe diſquiſitions have been ſo inſtructive to the learned world.

An ADVERTISEMENT.

THAT the reader may not wonder to find the following dialogue cited in the *Hiſtory of Cold*, whereunto nevertheleſs it is ſubjoined; he is to be informed, that a ſection about *Antiperiſtaſis* was really both written and tranſcribed before any part of that hiſtory was ſent to the preſs. But finding, that the acceſſion of new particulars had ſo much ſwelled it, that it was unfit to paſs (as I firſt deſigned it ſhould) for one of the titles of the *Hiſtory of Cold*, I judged it convenient to ſever it from the reſt, upon the ſcore of its bulk, and yet annex it to them upon the account of thoſe many hiſtorical paſſages in it, that belong to the ſame ſubject, that is handled in thoſe ſections. The reader will quickly find, that the tract conſiſts of two parts, whereof the firſt (which to allow the more freedom of inquiry and diſcourſe, written in the way of dialogue,) contains an *Examen* of *Antiperiſtaſis*, without pretending to queſtion it abſolutely and indefinitely, but rather, as it is wont to be taught and proved. And this dialogue, for reaſons, that it too little concerns the reader to know, and would take up too much time to tell him, both begins as a continuation of ſome former diſcourſe, and ſomewhere mentions the author, as a third or abſent perſon. And to make it the more like to other dialogues, the quotations are not made with the author's punctualneſs in the reſt of this book, but yet with his uſual faithfulneſs; nor hath his introducing

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men diſcourſing (as it were by chance) kept him from putting into the margin the very words of ſome paſſages, which he thought the moſt important and likely to be diſtruſted. But though this firſt part be entire and finiſhed in its kind, and ſo might very well (if not beſt) have been put forth ſingle, to invalidate the common doctrine of *Antiperiſtaſis*, (in the ſenſe wherein it is there oppoſed;) yet becauſe in philoſophical matters, it is not ſo much victory or applauſe, that is to be ſought, as truth; I forbore not to ſubjoin to a diſcourſe, that may perchance ſatisfy moſt of my readers, ſome ſcruples, about which I wiſhed for further ſatisfaction and certainty my ſelf; of the chiefeſt of which, the ſceptical conſideration will will give the reader an account.

The PUBLISHER to the Ingenious READER.

I AM fully perſuaded, you will much rejoice to ſee that exquiſite ſearcher of nature, the illuſtrious *Robert Boyle*, come abroad again, as knowing he never does ſo, but when richly furniſhed with very inſtructive and uſeful matter. He preſents you here with a treatiſe of *New Obſervations and Experiments, in order to an Experimental Hiſtory of Cold.* This is the body of the book; but it comes accompanied with ſome Preliminaries, and an Appendix, whereof the former contains *New Thermometrical Experiments and Thoughts*, the latter an *Exercitation* about the *Doctrine of Antiperiſtaſis*, followed with a ſhort *Examen of Mr.* Hobbes's *Doctrine, touching Cold.* From all which it will more and more become manifeſt, with what ſpirit and care this excellent perſon advanceth real philoſophy; with what exactneſs he purſueth his engagement therein; and how great caution he uſeth, that nothing may ſlide into the philoſophical ſtore, that may prove prejudicial to the axioms and theories hereafter perhaps to be deduced from thence.

HAVING thus ſhortly given you my ſenſe of the ſubſtance of this conſiderable treatiſe, I am now to advertiſe you of one or two circumſtances, neceſſary to be taken notice of in its peruſal.

ONE is, that the noble author being at *Oxford*, when the book was printed at *London*, he hopes the reader will not impute to him the errors of the preſs, which yet he is perſuaded will not be many, and out of which muſt be excepted a blank or two, occaſioned by this, that the author's papers being near two years ſince given to be tranſcribed to one, whoſe ſkill in writing was much greater, than (as it afterwards appeared) his knowledge of what was, or was not good ſenſe, or true Engliſh; this perſon ſuddenly going for *Africk* before the tranſcript had been examined, and not taking care to leave all the firſt copy, the author found, (beſides ſeveral blanks, that he filled up out of his memory, or by repeating the experiments, they belonged to) one or two, where he was not able to repair the copiſt's omiſſions: and beſides unexpectedly met with very many paſſages ſo miſerably handled, that by putting him to the trouble of writing almoſt a new book, when part of this was already in the preſs, it much retarded the publication of that, which now comes forth.

THE other is, that, whereas in the preface ſome paſſages are ſo penned, as to ſuppoſe the book to be publiſhed early in the winter, the reader is to be advertiſed, that the former part of this preface was ſent a good while ſince to the preſs, though the latter, however then written out, was hindered from accompanying it, by ſome hopes of the author's to gain by delay an opportunity (he miſſed of) to perfect an experiment he was deſirous to inſert; and that, when the froſt began, which was late in the ſeaſon, the coldneſs did within a while arrive at that degree, that by its operation upon the moiſtened paper, it long put a ſtop to the proceedings of the preſs. But the author, that he might neither be quite defeated of his aim, nor diſappoint the curious of their expectation, did in the firſt or ſecond week of the froſt, which was about the end of the year 1664, preſent the Royal Society with divers copies of the *Hiſtory of Cold*, though the book were not then quite printed off. And theſe books being ſo near finiſhed, that of twenty-one ſections, whereof the *Hiſtory of Cold* conſiſts, the preſs had then reached to about the 19th, and I had the 20th in my hands to ſupply it, when the weather ſhould permit; the author hoped, that by ſeaſonably communicating ſo much of his intended treatiſe to ſo many of the Virtuoſi, that were the likelieſt to make uſe of it, he had pretty well provided againſt the prejudice, that might otherwiſe accrue from the ſlowneſs of the preſs, and therefore allowed himſelf to ſubjoin to the hiſtory, the diſcourſe of *Antiperiſtaſis*, and the *Examen* of Mr. *Hobbes*'s doctrine *, as belonging to the ſame ſubject. And finding the froſty weather to continue later than was expected, (which had he foreſeen, before his hiſtory was printed off, it would have given him opportunity of enlargements) he hopes the publication may not be yet too late for diligent readers, to make ſome uſe of the ſeaſon for examining his experiments, or trying ſome of the new ones, thoſe may ſuggeſt. And therefore for the quicker diſpatch of the book, he purpoſely omits, and reſerves for another occaſion, beſides the papers, that he hath not yet given me, ſome that I have already in my hands. And it is, I preſume, for the ſame reaſon, that he forbears to publiſh, what he long ſince writ about the origin of forms and qualities, in a ſmall tract, which he had thoughts

* It was thought needleſs to inſert Mr. *Hobbes*'s ſcheme touching this ſubject, becauſe it only ſhews, that wind is the cauſe of cold.

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thoughts of ſending forth in the company of the enſuing hiſtory, as a diſcourſe fit to be an introduction as well to that, as to his hiſtorical writings about colours and ſome other qualities.

THIS is all the advertiſement I had to give you. And ſeeing it would be altogether impertinent, for me to take any pains, or to uſe any art to procure a guſt for a book, compoſed by Mr. *Boyle*, I have no more to ſay, but that the author being ſo generous as to oblige foreign nations as well as his own, has already taken care of having it put into Latin. Farewel.

London, March 10, 166⅘. *H. O.*

The Author's PREFACE *Introductory.*

COLD is ſo barren a ſubject, and affords ſo few experiments, that are either very delightful for their ſurpriſing prettineſs, or very conſiderable for their immediate uſe, that inſtead of admiring, that any of my friends ſhould wonder at my having been induced to write of ſuch a theme, I freely confeſs, that I have been ſometimes tempted to wonder at it my ſelf; and therefore I think my ſelf obliged to give my readers an account of theſe three things; Why I thought fit to write of cold at all? For what reaſons I have treated of it after the manner to be met with in the enſuing book? and, Why I venture my unfiniſhed collections about it, abroad ſo ſoon?

I. To ſatisfy the firſt of theſe queries, I have ſeveral of theſe things to ſay.

AND firſt, that the ſubject I have choſen is very noble, and important; for ſince heat has ſo general an intereſt in the productions of nature's phænomena, that (motion excepted, of which it is a kind) there is ſcarce any thing in nature, whoſe efficacy is ſo great, and ſo diffuſed, it ſeems not likely, that its antagoniſt, cold, ſhould be a deſpicable quality. And certainly cold, and heat, eſpecially when employed by turns, are the two grand inſtruments, by which nature performs ſo many of her operations here below, that our great *Verulam* did not ſpeak inconſiderately, when he called heat the right hand of nature, and cold her left: and though in our temperate climate the effects of cold ſeem not to be very remarkable, yet beſides that in more northern regions they are oftentimes ſtupendous, the nature of that quality muſt needs be very well worth our conſidering, if it were but for the power it has to moderate and check the operations of heat; upon which account alone, if there were no other, it may be looked upon as ſo conſiderable a quality, that even leſſer diſcoveries about it may both be acceptable and prove uſeful.

IN the next place I ſhall repreſent, that notwithſtanding cold's being ſo important a ſubject, it has hitherto been almoſt totally neglected. For I remember not, that any of the Claſſick authors, I am acquainted with, have ſaid any thing of it, that is conſiderable. They do indeed generally treat of it, as one of the four firſt qualities. But that, which they are wont to ſay, amounts to little more, than that it is a quality, that does congregate both things of like and unlike nature; the unſatisfactorineſs of which vulgar definition I had ſome years ago an occaſion to manifeſt (in another treatiſe, the *Sceptical Chymiſt*:) and having given us this inconſiderate deſcription of cold, they commonly take leave of the ſubject, as if it deſerved no further handling, than could be afforded it in a few lines, wherein indeed they ſay too much about it, but not enough. And even among other writers of bodies of natural philoſophy, or of the doctrine of meteors it ſelf, the reader will find, how little of true and pertinent has been contributed to the enſuing *Hiſtory of Cold*. And though among the vulgar, and the writers, that adopt their traditions without examining them, I find ſome few particulars delivered touching cold; yet ſome of them are ſo untrue, and others ſo uncertain, that they have furniſhed me with little elſe, than the neceſſity of queſtioning, or of diſproving them: ſo that when I conſidered all theſe things, I could not but take notice, that very little hath hitherto been ſaid of cold, by thoſe ſchoolmen, and other writers, (that I have yet met with) who have profeſſedly, (though but perfunctorily, and, as it were, incidentally) treated of it. But yet inſtead of thinking it a diſcouragement, that ſo many learned men, to whom that quality could not but be obvious, and to whom it was as familiar as to me, had in ſo many ages ſaid little or nothing of it to the purpoſe; I found this very thing an invitation to my attempt, that I might in ſome meaſure repair the omiſſions of mankind's curioſity towards a ſubject ſo conſiderable, and ſo diffuſed, by trying what I could do toward founding the hiſtory of a quality, which has been hitherto ſo neglected, as if all men judged it either unworthy of being cultivated, or uncapable to be improved.

ANOTHER inducement to me was, that having ſix or ſeven years ago written ſome tracts (though I have not ſince had opportunity to publiſh them) in order to the Hiſtory of *Heat* and *Flame*; it ſeemed the more proper for me to treat of the contrary quality, *Cold*; ſince, according to the known rule, confronted oppoſites give themſelves a mutual illuſtration. And another inducement of almoſt the ſame nature was afforded me by remembering, that whereas cold, in its higher degrees, is wont to be communicated

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communicated to us by the air, (whenceſoever the air has it) and I have on ſeveral occaſions been obliged to treat of divers properties of the air, as of its weight and ſpring (in my *Phyſico-Mechanical Treatiſe*) of the ſeveral ſtrengths of that ſpring, in proportion to the degrees of the air's condenſation; the experiments of which, reduced into tables, were firſt publiſhed (and for aught I yet know made) by us, (in the defence of that book againſt *Franciſcus Linus*,- chapter the fifth of that treatiſe) and of divers other qualities of the air in ſeveral paſſages of our other writings, which it were now ſuperfluous to take notice of; all this made it appear convenient enough, that among other attributes of the air, which we either have had, or expect to have occaſion to treat of, ſo eminent and diffuſed a one as its coldneſs ſhould not be left untouched by the ſame pen.

But though neither any, nor all theſe inducements had been ſufficient to engage me to draw together, and recruit my obſervations concerning cold, there was another, that could not miſs of prevailing, the command of the Royal Society, impoſed on me in ſuch a way, that I thought, it would leſs miſbecome me to obey it unſkilfully, than not at all. Eſpecially ſince from ſo illuſtrious a company (where I have the happineſs not to be hated) I may in my endeavours to obey and ſerve them, hope to find my failings both pardoned, and made occaſions of diſcovering the truths, I aimed at.

II. After this account of the motives, that induced me to reſolve to draw together the notes I had on ſeveral occaſions ſet down, about the phænomena of cold, it may be now expected, that I render ſome reaſon, why I have thus digeſted them, and why I have not written the following treatiſe in a more accurate way.

Firſt, then I readily acknowledge, that the method is not exact. Nay, that it is leſs ſo than the ſcheme of heads of inquiry, that I drew up, to give my ſelf a general proſpect of the ſubject I was to handle. But when I had conſidered, how comprehenſive a theme I had pitched upon, and how much more comprehenſive, future diſcoveries and hints might make it, I thought it altogether unadviſeable for me, that had no more time, nor no more opportunity than I had, when I begun to compile the following hiſtory, to engage my ſelf to a method, according to which I was not perhaps able to treat of any one of the principal parts of the deſigned hiſtory. And yet, on the other ſide, being unwilling to huddle my experiments confuſedly together, I thought it an expedient, that might in great part decline both thoſe inconveniencies, to draw up a company of comprehenſive titles, under which might commodiouſly be ranged moſt of the particulars I had obſerved, reſerving thoſe few, that were not ſo eaſily referrible to any of thoſe, to be thrown at laſt into a ſection by themſelves. And this I the rather did, becauſe I would not, by a confinement to a ſtrict method, diſcourage others from continuing the hiſtory, by adding new titles to thoſe twenty-one, I have treated of, as well as by inſerting other experiments or obſervations in any of them.

That the ſections or titles are very unequal, will not, I preſume, be much blamed by them, that conſider, that my deſign being to ſet down matters of fact, not write a complete and regular treatiſe, the length of each ſection was to be determined, not by its proportion to that which went before it, or followed after it, but by the number and condition of the particulars, that were to compoſe it. And I thought it much more pardonable, that any of the ſections ſhould be diſproportionately ſhort, than lengthened either by untruths or by impertinencies.

Some of the accounts will probably to ſome readers appear too prolix; and I could very eaſily, as well as willingly, have prevented that objection, if I had not more conſulted the ſcope of the book, than the eaſe or reputation of the writer. But my deſign being, not only to gratify ſome readers, but to aſſiſt others to proſecute the work I had begun, as the experiments are moſt of them new, and many of them tried by methods hitherto unpractiſed; I conceived my ſelf obliged to ſet down ſomewhat circumſtantially, not only the events, but the manner of my trials, that I might at once, both the better ſatisfy the ſcrupulous, and be aſſiſtant to thoſe, that would examine or repeat ſuch experiments, and alſo gratify thoſe, who are pleaſed to think, that a ſomewhat aſſiduous converſation with nature may have given me ſome little faculty in deviſing experiments, and the ways of making them, above thoſe, that have been converſant only with books and notions. And in ſome of the following trials I was the more induced to ſet down all the principal circumſtances, becauſe that being not to be made, but by the help of glaſſes ſkilfully ſhaped, and hermetically ſealed, and other inſtruments and operations, that require more tools, and more of manual dexterity, than every ingenious man is maſter of; it is very likely, that moſt readers will not be able, or perhaps willing, to reiterate ſuch trials, and therefore will be glad to find them ſo delivered, as that they may without too much danger acquieſce in them, as being made with diligence as well as faithfulneſs. The latter of which qualities will, I preſume, be allowed me, as well upon the account of the plain and ſimple way, wherein matters of facts are delivered in the following book, as upon the ſcore of the teſtimonies, that even adverſaries, as well as others, have thought fit to give to the hiſtorical part of my former treatiſes. And (to intimate that on this occaſion) this ſtrict fidelity to truth I ſcruple not to own, though perhaps it may be attended with an inconvenience in point of reputation, that writers of leſs veracity are expoſed to. For I have found by experience, that ſome men, who probably would not mention the experiments of moſt others, without vouching their authors, for fear of loſing their own credit, in caſe the thing related ſhould not prove true, have, without taking the leaſt notice of me, made uſe of ſuch experiments of mine, as I have ſtrong motives to think they never made nor ſaw, only becauſe

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they had been related by one, after whom they thought they might without a hazard of their credit deliver any matter of fact. And the liberty, that ſome have allowed themſelves in adopting my communications (ſuch as they are) is notorious enough to have been publickly complained of more than once, by perſons, that are meer ſtrangers to me. But though I had not the probability, which the notice, that begins to be taken of it, ſeems to give me, of having ſome juſtice done me; yet veracity is a quality, that does, I think, ſo well become a Chriſtian and a writer of natural hiſtory, that I had much rather undergo any diſadvantage, I may be ſubject to for it, than decline the practice of it. But to return to the following hiſtory.

I CONFESS the prolixity of ſome paſſages of our hiſtory is increaſed by the tranſitions, excuſes, and ſuſpicions, that are made uſe of in them; but I confeſs too, that if this way of writing be a fault, it was not always cauſed by inadvertency. For as to what is ſaid to connect the parts of our hiſtory together, or excuſe the not proſecuting of this or that particular trial, the heedful reader may oftentimes perceive, that they contain in them, though not perhaps conſpicuouſly, either cautions, or advertiſements, or hints, not impertinent to my main ſcope, and improveable by an attentive peruſer. And as for the ſuſpicions and ſcruples, to which now and then I may ſeem to have too long indulged, I had two or three inducements to invite me to what I did. For the mention of conjectures, that every reader was not ſo likely to light upon, might more conduce, than at firſt one would think, to the main deſign of my book, which was to begin, and promote the natural hiſtory of cold; ſince theſe ſuſpicions about the cauſes and ſcruples about other things, relating to our experiments, may probably produce, not only new reaſonings and inquiries, but new trials, to clear the difficulties, and determine the doubts. Beſides, I thought it not amiſs to take ſuch occaſions to make ſome readers ſenſible, that to make indubitable inferences even from certain experiments is not near ſo eaſy a work, as many are pleaſed to imagine. And whereas I was not without inducements to think, that ſome critical and ſagacious readers will not only excuſe my having taken notice of ſo many ſcruples, but wiſh I had moved more on ſome occaſions, and propoſed ſome in certain caſes, where I have not mentioned any, I thought it might invite ſuch jealous readers to think, that I foreſaw divers little difficulties and ſcruples, that might be moved in ſeveral caſes, where I have not expreſly taken notice of them, either becauſe I judged them eaſy enough to be anſwered without my help, or becauſe the things themſelves were not conſiderable enough to deſerve a long or ſollicitous diſcourſe to clear them, eſpecially from a writer, that being often tired himſelf in examining ſuch niceties, was afraid he ſhould too much tire the generality of his readers, if he ſhould too frequently inſiſt upon them.

IF it be objected, that notwithſtanding ſome things are ſet down prolixly, yet other experiments, that might properly be referred to ſome of the titles I handle, are wholly omitted; I anſwer, that this were indeed a fault in one, that ſhould pretend to write full and accurate diſcourſes of the ſubjects propoſed in his titles, but not in me; who do not at all pretend to ſay, under each head, all that may be pertinently referred to it, (for that may probably be a great deal more, than is yet come to my knowledge) but only thoſe particulars, that I myſelf have tried or obſerved, or at leaſt have received upon credible teſtimony. And, perhaps, ſome amends may be made for theſe omiſſions, by my having frequently enough mentioned the experiments, that, when I propoſed them, I had only deſigned or attempted without perfecting them. For the experience of many ages has ſhewn us, that hitherto, not only men do not appear to have made any ſtore of trials concerning cold, but ſeem not to have ſo much as deſigned it. And therefore it ſeemed not unreaſonable to preſume, that it would prove an aſſiſtance to the generality of readers, if probable and practicable experiments were propoſed to them. And ſince it is the improvement of the ſubject that I aim at, by whomſoever it may happen to be improved, I thought it but reaſonable to uſe my endeavour, that thoſe experiments, which for want of opportunity I myſelf could not try, might be tried by others, who may be befriended by more favourable circumſtances. Nor is that great ornament and guide of philoſophical hiſtorians of nature, the Lord *Verulam* himſelf, aſhamed to ſubſtitute, on I know not how many occaſions, his *fiat experimentum*; that is, a precept or a wiſh to have an experiment made, inſtead of an account of the experiment made already. And yet in this mention of things, I could wiſh to have tried, I have been far more ſparing than every reader will take notice of. For I judged it not diſcreet to mention all the experiments I had thought upon, or even already ſet down in ſeveral catalogues, leſt they ſhould appear extravagant to thoſe, that are unacquainted with the ſeveral notions, and trials, and contrivances, which made them appear to me not irrational, and which yet it would have been tedious, and not worth while to have particularly mentioned.

BUT that in what we have newly (and a little before) had occaſion to ſay of our ways of making experiments, our meaning may not be miſconſtrued, we muſt here advertiſe the reader, that though, in many of the following experiments, the contrivances will not, perchance, be diſliked, yet, in many others, they are far enough from being ſuch, as might have been propoſed by one, that had wanted no accommodations fit for ſuch a work as ours. But I was reduced to make many of thoſe experiments in a village; and whilſt I was writing them, was obliged to make frequent removes, by which means I ſeldom had the liberty to make my trials after ſuch a manner, as I could contrive them, if I could have inſtruments and other

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other assistance to my wish. For sometimes I wanted conveniently-shaped glasses; sometimes the implements necessary to seal them up with; sometimes such ingredients, as I needed to work on; oftentimes frosty weather, for the freezing of bodies to be exposed to the open air, and not seldom ice and snow for artificial congelations; sometimes weather-glasses, especially sealed ones, two of which being unluckily broken after one another, kept me from being able to make divers considerable experiments; sometimes tender scales, and sometimes other mechanical instruments of several sorts, and more than sometimes (for it happened very frequently) I wanted time so to prosecute and finish the experiments, as to satisfy myself about divers circumstances, which, though possibly few readers will take notice to be wanting, I would gladly have observed, if I had not been hindered, not only by the haste I was often fain to make for fear of losing a frost, but the importunities both of other avocations, and even of the distraction given me by the multitude of experiments, which haste made me prosecute at once. And indeed, as in divers others of the treatises, I have occasionally written, so particularly in a great part of this *History of Cold*, my writing in places, where I wanted such mechanical accommodations, as I could have wished for, and devised, has reduced me oftentimes both to leave experiments untried, that would have much illustrated my subject, or cleared the difficulties of it, and contrive several of those I mention, not after the best manner that might be, but after the best manner, that was practicable by the accommodations I was then able to procure: so that it need not be wondered at, or blamed, if in some passages of these papers, experiments to the self-same purpose are more accurately tried, or by more expedient ways at one time than another. For as a physician, if he come to practise in the country, where apothecaries shops are but ill furnished, both as to the number and as to the quality of the drugs, must accommodate his practice to the scant *materia medica*, of which alone he has the command: so when I write of experimental matters, in places where I cannot have workmen, nor instruments fit for my turn, I must be content to vary my experiments accordingly, and suit them to the accommodations I am confined to; which, though it be an unwelcome condition, is made the less so to me, by a hope, that the equitable readers will think it to be all, that a man is bound to do in such cases, to procure the best assistances he can, and manage those, he is able to procure, to the best advantage.

And this I rather take notice of on this occasion, that ingenious men might not be too much discouraged by imagining, that, because they live in the country, or upon other scores, cannot furnish themselves with the best instruments and accommodations, nor enjoy the assistance of the skilfullest artificers; they are either unqualified for the making of experiments and observations, or superseded from it. For though, in some cases, where the measures of things must be nicely determined, and principally in observations, whereon either theorems or hypotheses about the proportions of things are to be grounded, very good instruments are exceeding useful, and sometimes necessary; yet there are thousands of particulars, whose knowledge may be instructive to those, that are or would be Naturalists, where no such nicety is requisite, and where the measuring things by ounces and inches will serve the turn, without determining them to lines, and grains. And even in cases, where exact observations are (to some purposes) requisite, those, that are not so, may be oftentimes very useful, by affording hints, by which others may be excited and assisted to make those more accurate trials. And here let me take notice, that a tool or instrument is not therefore to be despised, if it be proper enough to the particular use, to which it is applied, because some more mechanical head or hand may propose or make another, that is more artificially contrived, or more neat and portable, or that will also perform other things, than that we are speaking of. For there is a vast multitude of physical phænomena, wherein mathematical exactness is not necessary, and observations about these may be well enough made by divers other ways, than by the most artificial, that can be devised. As though a fine watch may have these advantages, that it is a neater thing, and more portable than an ordinary clock; that it may be improved by the addition of an alarum, and that it may also, perhaps, shew the day of the month, the age of the moon, the tides, and divers other things, of which the clock shews not any: yet an ordinary clock may serve to measure an hour by, as well as this finer engine; and so may a sun-dial, and many other instruments on divers occasions; though in other cases, and other regards, they be far less commodious, than either a watch or clock. Besides, that in many cases a skilful Naturalist will, by a variety and collation of experiments, make the same discoveries, and perform the same things, for which others be wont to be beholden to instruments, and perhaps do many things without them, that have never been done with them. And since necessity is proverbially allowed to be the mother of inventions, even in tradesmen, and vulgar heads, why should we doubt, but that the rich and inventive intellect of a philosopher may, in cases of necessity, turn itself, and contrive the things it can dispose of, into so many differing forms, that it will often make its own sagacity and industry supply the want of exact tools and instruments? And these considerations, that tend to keep ingenious men from despondency, I therefore think fit to inculcate, because the commonwealth of learning would lose too many useful observations and experiments, and the history of nature would make too slow a progress, if it were presumed, that none but geometers and mechanicians should employ themselves about writing any part of that history.

But to return to those trials of our own, that occasioned this (as I hope, seasonable) digression,

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digreſſion, I was about to add, that as the acknowledgment I was making, that ſome of the trials were, for want of accommodations, leſs artificial than I could have deſigned or wiſhed them, touches not all, nor haply the greateſt part of the following experiments; ſo it need not derogate from the reader's reliance on thoſe, which it does concern. For though ſome of them might have been more artificially performed to the manner, yet they could not have been more faithfully regiſtered, as to the events. Which though I dare promiſe myſelf, that moſt readers will be induced to believe, upon the conſiderations not long ſince intimated; yet I think it requiſite to give this intimation on this occaſion, becauſe, that though I have (in the two eſſays of the *Unſucceſsfulneſs of Experiments*) largely manifeſted to what contingencies divers experiments are liable, yet I have found very few, whoſe events are ſo ſubject to be varied, by ſlight and not eaſily heeded circumſtances, as ſeveral experiments concerning cold; where oftentimes the degree of that quality, or the time during which it continues applied, or the manner of application, or the thickneſs, ſhape and bulk, *&c.* of the veſſels, that contained the matter expoſed to it, may have a far greater influence on the ſucceſs, than thoſe, that have not tried, can eaſily imagine. And it increaſes the difficulty, that theſe experiments of ours being (very few excepted) the only, that are yet made publick concerning cold; we cannot ſo eaſily, as in other caſes, free ourſelves from the doubts, that may be ſuggeſted by different events, by comparing together ſeveral experiments of the ſame kind; though to obviate this inconvenience, as far I may, I have divers times in caſes, where the experiments ſeemed like to be thought ſtrange, or to be diſtruſted, ſet down ſeveral trials of the ſame thing, that they might naturally ſupport and confirm one another.

Of thoſe contingent experiments about cold, I was newly ſpeaking of, the reader may meet with an eminent example in the 21ſt title, where mention is made of the differing effects of air blown out of a pair of bellows upon a weather-glaſs: and as for the ſuſpicion I there conclude with, (though I yet doubt, whether it will reach all the caſes incident to that experiment) I have ſince been confirmed in it, by finding, that by purpoſely varying the temper of the bellows themſelves, I could divers times conſiderably vary the operations, which the winds, blown out of them in their differing ſtates, had upon the liquor in the weather-glaſs *. Of this I expect to have an opportunity of ſaying more, and therefore ſhall at preſent add but this one particular, which may ſufficiently juſtify me for having ſaid, that weather-glaſſes and our ſenſories may give very differing informations about the temperature of the air turned into wind, by being blown out of the ſame pair of bellows. For having taken two hermetically-ſealed weather-glaſſes furniſhed with highly rectified ſpirit of wine, and purpoſely made for my experiments by a perſon eminently dexterous in making ſuch inſtruments, and having likewiſe provided a large pair of bellows, I found, that by blowing twenty blaſts at a time on the ball of one of them, though the pipe were not only ſlender, but of an unuſual length, amounting to about thirty inches, yet the liquor did not ſenſibly ſubſide any more than riſe. And in the other weather-glaſs, whoſe pipe was leſs long, but whoſe ball was purpoſely made far greater to be the fitter for ſhort and nice experiments, we found more than once, and (that as well in the cold air, as in a cloſe room) that the wind, that was blown in divers blaſts out of the bellows againſt the lower part of the inſtrument, did not only make the ſpirit of wine ſubſide, but did make it manifeſtly, though but very little, aſcend. And it is not neceſſary, for the making good of what I taught, that ſuch trials ſhould always ſucceed juſt as theſe did, ſince it may ſuffice to prove what I pretended, that a good ſealed weather-glaſs did divers times diſcover the wind to be rather warm, than cold, when upon trial (then purpoſely made) it felt not only manifeſtly, but conſiderably cold, both to a by-ſtander's hand, and to my own hand and face, though my hand, that was blown upon, were immediately before more than ordinarily cold.

And I ſhall here add, that judging it fit to make further trial with an unſealed weather-glaſs, I made one, that was in ſome regards preferable to thoſe mentioned in the ſecond preliminary diſcourſe, by making the bubble large, and the cylindrical pipe ſo proportioned to it, that inſtead of a drop of water, a pillar about an inch long of that liquor was kept ſuſpended, and played as well conſpicuouſly as nimbly up and down in the pipe: and having faſtened this inſtrument in an erected poſture, with the ſpherical part uppermoſt, to the inſide of a window, by blowing upon the ball with the bellows above-mentioned, which had lain ſome hours not very far from the chimney-corner, (but without ſeeming to be ſenſibly warmed by the neighbourhood of the fire) a very few blaſts made the ſuſpended water haſtily ſubſide, (and thereby witneſs the expanſion, and ſo the warmth of the included air;) and upon my ceaſing to blow, the ſame water would re-aſcend in the pipe, and that, though I ſtood near it to watch it, (which ſhews, that the former depreſſion was not cauſed by the approach of my warm body) and this I did more than once both alone and before witneſs, notwithſtanding that the air blown at the ſame time out of the ſame bellows upon our hand and face ſeemed cool

* Another remarkable inſtance of the variable ſucceſs of the experiments of cold I have met with in an experiment of the learned Dr. *Merret's*, about the congealing of oil of vitriol. For though I expoſed that liquor in ſmall veſſels of differing ſizes and ſhapes, and even in ſlender glaſs pipes, ſealed but at one end, yet neither the cold of the air in froſty nights, that were extraordinarily ſharp, nor, which is more, our frigorifick mixture of ice and ſalt, would make the experiment ſucceed; notwithſtanding that we tried it with ſeveral parcels of oil of vitriol. And yet, that the learned doctor by the help of the air alone (for he uſes not our frigorifick mixture) did bring that liquor, either to a true congelation, or a coagulated ſubſtance, that looked juſt like ice, both ſome eminent Virtuoſi, and I my ſelf, who had the curioſity to examine it, can bear him witneſs.

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cool enough. But fearing to inſiſt any longer in this matter in a Preface, I think it now unſeaſonable to add, that as ſome contingent experiments in ſubſequent trials may fail oftener, ſo others may, perchance, ſucceed oftener than is expected: as I have ſometimes obſerved in the figures, that appear in the ice made of ſome liquors, that abound with volatile, urinous, or with certain other ſalts. But to ſay a word in general of experiments, whoſe ſucceſs is not always uniform; as a magnetick needle, though it do not always preciſely reſpect the poles, but both declines ſometimes eaſtward, and ſometimes weſtward, and varies that declination uncertainly as to us, does nevertheleſs ſo far reſpect the North, as in ſpite of its variations to be an excellent guide to navigators; ſo there are contingent experiments, whoſe events, though they ſometimes vary, are ſeldom very exorbitant, but for the moſt part are regular enough to afford philoſophers very uſeful informations and directions.

If it be demanded, why in the 15th, 18th, and 19th ſections I have inſerted ſo many quotations out of ſeveral authors, and how that agrees with what I have ſaid, not far from the beginning of this Preface, of the uncultivatedneſs of the ſubject I have adventured on; I anſwer, that what I have done croſſes not what I have ſaid. For my complaint was, that there has been very little, eſpecially of any moment, delivered concerning cold, by claſſick authors; and that even other learned writers, who have had occaſion to ſay ſomething purpoſely of cold, have handled it exceedingly jejunely: but this hinders not, but that if a man will take the pains to ſeek out, and inquire of travellers, and has the curioſity to conſult voyages and navigations, he may, among a multitude of other things, that have nothing to do with cold, meet with ſome few, that concern that ſubject: and yet the authors, that deliver ſuch particulars, can no more properly be ſaid to have written profeſſedly of cold, than of botanicks, or zoology, or meteors, or civil philoſophy, becauſe in the ſame journal they mention a great froſt, or a great ſnow, as chancing to happen on ſuch a day, with as little particular deſign, as they mention a ſtorm, or a whale, or a bear, or the manners of an Indian people. This conſideration being premiſed, it will not be difficult to return an anſwer to the former part of the queſtion lately propoſed. For the unfrequency of my quotations in moſt of the ſections of the following hiſtory will, I preſume, ſufficiently perſuade the reader, that I would not needleſly employ ſo many of them in the three ſections, that are named in the quotation. But the writers of phyſicks being, for aught I know, ſilent as to the particulars I have tranſcribed out of other writers, and the obſervations being ſuch, as I could not my ſelf make in this temperate climate; I muſt either make uſe of other men's teſtimonies, or leave ſome of the remarkableſt phænomena of cold unmentioned. And they, that ſhall try, how much pains it will coſt them, to range among books, which many of them contain little but melancholy accounts of ſtorms and diſtreſſes, and ice, and bears, and foxes, to cull out here and there a paſſage fit to make a part of ſuch a collection, as they may here meet with, will poſſibly rather thank, than blame me, for having, to gratify my readers, given my ſelf ſo laborious and unpleaſant an entertainment. And I was the rather content to enlarge a little on the forementioned occaſions, not only becauſe I was unwilling to be engaged more than once in ſo troubleſome an employment, but (and that chiefly) becauſe moſt of the particulars, I have collected out of navigators, are afforded me by the voyages of our own countrymen, who having written only in Engliſh an account of what their relations contain of moſt material concerning cold, will probably be welcome, as well as new, to the curious of other countries, who cannot underſtand their books; divers of which having been long out of print, are ſo hard to be procured, even here in *England*, that I doubt not, but theſe extracts of them will be acceptable, even to divers of the virtuoſi of our own nation; eſpecially ſince I have been careful to alledge moſt of the teſtimonies in the writer's own words, though they are not always the beſt, wherein the things he delivers might be expreſſed. And this courſe I the rather took, that I might do what I think very uſeful to be done by all writers of natural hiſtory, who would do well to diſtinguiſh more carefully, than hitherto many have done, betwixt the matters of fact, they deliver as upon their own knowledge, and thoſe, which they have but upon truſt from others. I know it would be more acceptable to moſt readers, if I were leſs punctual and ſcrupulous in my quotations; it being by many accounted a more genteel and maſterly way of writing, to cite others but ſeldom, and then to name only the authors, or mention what they ſay in the words of him, that cites, not theirs, that are cited. And there are ſome writers of ſuch known diligence and veracity, as to be ſafely truſted, and ſome caſes, wherein I do not diſlike, but comply with this cuſtom, (after having firſt conſulted my author to be maſter of his true and genuine ſenſe;) but in matters hiſtorical, and whereon philoſophical and important truths are to be built, I ſhould think my ſelf beholden to a writer, for ſetting them down in ſuch a way, as that I may ſatisfy my ſelf, that the teſtimony is faithfully reported. In order to which, it will be ſometimes very uſeful to be enabled to repair to the original witneſs, and, if need be, ſurvey there the context of the alledged paſſage. For I muſt here advertiſe the reader, that in matters of any moment, it is not from every writer, that I dare truſt the quotations he makes of the paſſages of other authors, in his own words, not theirs: for upon comparing very many quotations, I have found, that oftentimes there is no ſuch thing, as is pretended to be really met with in the place referred to; and even when neither the book, nor chapter, nor page are miſquoted, I have too frequently found, that the alledgers of teſtimonies do either, through inadvertency, miſapprehend, or miſrecite the ſenſe of the author they quote, or out of deſign make him ſpeak that, which

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may comply with their own purpoſe, whether it were his own ſenſe or no : and by their indefinite citations made it too troubleſome and difficult a work, for the reader to find out, whether they have impoſed upon him or not. But it is only by the by ; to return therefore to the paſſages we were ſpeaking of, in the 15th, 18th, and 19th ſections, I ſhall now add, that having in the beginning of the XIXth title of the enſuing hiſtory itſelf rendered an account of my not ſcrupling to aſſert ſome ſtrange relations concerning cold, it will not be requiſite to mention here, what the reader will meet with there. And I ſcarce doubt, but he will excuſe ſuch paſſages, if we conſider, that as I could not omit them, without leaving out ſome of the eminenteſt phænomena of cold, ſo being unable to examine them here in *England*, all I could do was, to report them faithfully, and mention only ſuch, as were either affirmed by eye-witneſſes (as the moſt I have inſerted, are) or, at leaſt recommended by credible teſtimony, whereof we ſhall ſay more by and by ; to which ſort of narratives I know not whether I may refer that, which (yet for its ſtrangeneſs may deſerve a tranſient mention,) came a-while ſince to my ears, of an Engliſhman, who related to an eminent virtuoſo of our acqaintantance, that a Dutch maſter of a ſhip, returning from the northern countries, very ſolemnly affirmed, being therein ſeconded by one of his countrymen, and offered to produce his journal for proof, that endeavouring to ſail northwards as far he could, he came within leſs than a degree of the pole itſelf, and found the ſea open, and the cold very tolerable. But to return to what we were ſaying, before this odd relation diverted us, I did not only decline the mention of divers things, with which I fear many writers would have adorned a hiſtory of cold ; but even of thoſe, that I my ſelf, have inſerted, I would have left outdivers, were it not, that many of the relations, that may appear ſo wonderful, ſeem not to me to be repugnant to the nature of things, but only ſuppoſe a far greater degree of cold, than we have in theſe parts; and yet the familiar effects of the cold we have here, would, perhaps, be looked on as incredible, by one, that was born and bred in the kingdom of *Congo*, where *Odoardus Lopez*, who lived long there, inſorms us, that ice, that is, water made ſolid, is ſo known a rarity, that it would there be valued as ſo much gold. And a learned phyſician, that lived in *Jamaica*, being aſked, how far he found the temperature of that country to be like that of *Congo*, anſwered me, that in that iſland he obſerved not all the winter long, either froſt or ſnow. And yet here it will not be unſeaſonable to ſay a word or two of the three principal authors, from whom moſt of our ſtrange relations we are conſidering are tranſcribed.

THE firſt is *Gerat de Veer*, who writ the voyage of the Hollanders to *Nova Zembla*, a book ſo eminent in its kind, that it may ſeem a waſting of time to ſet down a character of it ; and therefore I ſhall only advertiſe the reader of two things ; the one, that the Dutch did, indeed, make three conſecutive voyages to *Nova Zembla* ; but that the third being that, in which they wintered there, moſt of the particulars are to be underſtood of that. The other thing is,that having loſt the tranſlation, that was made of thoſe voyages out of Dutch into Engliſh, (publiſhed in a book by themſelves,) without being able to procure another, I was obliged to have the citations tranſcribed, as I found them extant in that faithful collection of voyages compiled by *Purchas* ; who ſeems, by the ſtyle, to have (as to the book we are ſpeaking of) only plaid the part of an interpreter. And here it will be ſeaſonable to add, that whereas that excellent collection conſiſts of ſeveral diſtinct tomes or volumes, the many quotations to be met with, in the margin of our hiſtory under the name of *Purchas*, are to be underſtood, (unleſs the contrary be intimated) to belong to the third part of his *Pilgrim*, where the Dutch and other voyages into the northern countries are to be found.

THE next book I intend to mention, is *Olaus Magnus*'s Hiſtory of the Northern Nations. And though this author is of very ſuſpected credit, and delivers ſome things upon hear-ſay, which they are kinder to him, than I, that are pleaſed to believe ; for which reaſon I do but very ſparingly make uſe of his hiſtory ; yet, conſidering, that he was archbiſhop of *Upſale* in *Sweden*, and appears to have more learning, than many, that never read his books, imagine ; I thought I might, now and then, make uſe of his teſtimony, in matters, wherein he either profeſſes himſelf to ſpeak upon his own knowledge, or delivers but ſuch things, as being conſiſtent with the laws of nature, appear improbable, only, becauſe of the intenſe cold, that they ſuppoſe : which I the rather ſay, becauſe he himſelf ſomewhere ſpeaking of the cold, that by the laws of nature reigns in the North, ſubjoins this paſſage, (*Lib.* 1. *Titulo de frig. aſperitate*, page 9.) *Sub quo quia natus, & verſatus ſum etiam circa elevationem graduum poli arctici* 86, *arbitror me poſſe hoc, & multis ſequentibus capitulis, nonnihil cæteris vaga opinione ſcribentibus clarius demonſtrare, quam vehemens & horrendum ſit illic frigus.*

AND, though perchance few readers will perceive it, I have been ſo ſevere in rejecting not only relations, but even authors not otherwiſe obſcure, that, how much ſoever I foreſaw my ſcrupulouſneſs might impoveriſh my hiſtory, yet there are ſome whole treatiſes about cold countries, whence I have ſhunned to borrow any one authority, becauſe I perceived the authors had not obſerved the things they recount themſelves, and were too eaſy in believing others.

THE third writer I meant to take notice of, is captain *James*, a perſon from whoſe journal I have borrowed more obſervations, than from thoſe of any other ſeamen, not only becauſe his book ſupplied me with them, and becauſe it is ſomewhat ſcarce, and not to be met with in *Purchas*'s tomes, (having been written ſome years after they were finiſhed) but becauſe this gentleman was much commended to me,

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me, both by ſome friends of mine, who were well acquainted with him, and by the eſteem, that competent judges appear to have made of him. For having been, not only imployed by the inquiſitive merchants of *Briſtol*, to diſcover a north-weſt paſſage into the South-ſea, but deſigned for ſo difficult a work by ſo judicious a prince, as the late king, and having, at his return, publiſhed his voyages by his Majeſty's command; as by theſe circumſtances, though not by theſe only, this gentleman's relations may well be repreſented to us, as likely to deſerve our conſideration and credit; ſo, by his breeding in the univerſity, and his acquaintance with the mathematicks, he was enabled to make far better uſe than an ordinary ſeaman would have done, if the opportunity he had to obſerve the phænomena of cold, by being forced to winter in a place, where he endured little (if at all) leſs extremity of cold, than that of *Nova Zembla*.

I PRESUME it will eaſily be taken notice of, that in the following hiſtory I have declined the aſſerting of any particular hypotheſis, concerning the adequate cauſe of cold. Not but that I may have long had conjectures about that matter, as well as other men, but I was willing to reſerve to myſelf an intire liberty of declaring what opinion I moſt inclined to, till the hiſtorical part being finiſhed, I may have the better opportunity to ſurvey and compare the phænomena; and the leiſure, (which I cannot promiſe myſelf in haſte) of calmly conſidering what theory may beſt agree with them: eſpecially ſince I freely acknowledge, that I found the framing of an univerſal and unexceptionable hypotheſis of cold to be a work of greater difficulty, than every body would imagine; eſpecially to me, to whom ſome experiments, purpoſely made, have ſuggeſted a puzzling difficulty, which it is like that philoſophers have not yet thought of. And whatever applauſe is wont in this age to attend a forwardneſs to aſſert hypotheſes, yet, though fame were leſs to be ſought than truth, this will not much move me, whilſt I obſerve, that hypotheſes haſtily pitched upon do ſeldom keep their reputation long; and divers of them, that are highly applauded at the firſt, come, after a while, to be forſaken, even by thoſe, that deviſed them.

As for the title of the following book, I call the experiments new, becauſe indeed, if I miſtake not, nine parts of ten (not to ſay nineteen of twenty) are ſo. But though 150, or 200 experiments of that kind, beſides collections from travellers, and books, that do not profeſſedly treat of cold, may, I preſume, allow me to have begun the natural hiſtory of cold; yet, in the very title-page I think fit to intimate, that I look upon what I have done but as a beginning. For though ſome very noted virtuoſi have been pleaſed to ſeem ſurprized, to ſee what ſo barren and uncultivated a ſubject has been brought to afford this treatiſe; yet I look upon theſe as things, that do rather promiſe than preſent a harveſt, and but as ſome early ſheaves of that crop, which men's future induſtry will reap from a ſubject, that is indeed barren, but not unimprovable. For I ſee not, why it ſhould not hold in the hiſtory of cold, as well as in many other attempts, that the greateſt difficulties are wont to be met with at the beginning; and thoſe being once ſurmounted, the progreſs becomes far more eaſy. And as the magnetick needle, though it point directly but at the north and ſouth, does yet diſcover to the ſeaman the eaſt and weſt, and all the other points of the compaſs; ſo there are divers experiments, which though they do primarily and directly teach us but a notion or two, may yet aſſiſt us to diſcover, with eaſe, many other truths, to which they ſeemed not at firſt ſight to afford us a direction. So that what is here already done, ſuch as it is, partly by hinting various inquiries about cold, and partly by ſuggeſting ways not formerly practiſed of making farther experiments, may poſſibly make it more eaſy for others to add to theſe a number, far exceeding that, which they will here meet with, than it would have been without ſuch aſſiſtances, (which I had not) to contribute to the Hiſtory of Cold, even ſuch a ſtock as I have begun it with. And this I the rather incline to think, becauſe I find, that when once a man is in the right way of making inquiries into ſuch ſubjects, experiments and notions will reciprocally direct to one another, and ſuggeſt ſo many things to him, that if I were now to begin this work again, and had cold, and fitly-ſhaped glaſſes, and inſtruments, with other accommodations at command, there are divers parts, on which my inlargements would not, perchance, be much inferiour to what is already extant there, if they did not much exceed it. But beſides that I have other work enough, and that of a quite other nature upon my hands; the truth is, that I am plainly tired with writing on this ſubject, having never handled any part of natural philoſophy, that was ſo troubleſome, and full of hardſhips, as this has proved; eſpecially becauſe that not only the experiments being new, and many of them ſubject to miſcarriages, required to be almoſt conſtantly watched, but being unable to produce or intend cold, as we can do heat, nor command the experiments, that concern congelation, with as little difficulty, as we can do thoſe, that belong to divers other ſubjects; I was fain to wait for, and make uſe of a fit of froſty weather (which has very long been a rarity) as ſollicitouſly as pilots watch for, and improve a wind.

III. IT remains now, that I give ſome account, why I ſuffer ſo unfiniſhed a piece, as I acknowledge this to be, to come forth at this time. And I confeſs, that if I had not preferred the gratifying the curious, before the advantages of my reputation, I ſhould have kept this book in my hands ſome winters longer, that it might come forth, both more rich, and leſs unpoliſhed. But how great a power my friends have with me in ſuch caſes, the reader may eaſily gueſs by the preamble he will find prefixed to the firſt title of the enſuing hiſtory. For by the date of that, he will ſee, how early my papers about cold were to have been communicated; nor was I any thing near

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ſo much befriended, as I expected, by thoſe interpoſing accidents, that have for above a year and half kept thoſe papers lying by me. For the then next, and now laſt winter proved ſo ſtrangely mild, as to be altogether unfavourable to ſuch a work as I had deſigned. Wherefore finding, that delays had done me no more ſervice, and preſſed by the ſollicitations of divers virtuoſi from ſeveral parts, I reſolved, that I would ſuſpend till another opportunity the drawing together of what I had obſerved or collected, touching the regions of the air, and ſome of the chief hypotheſes, that are controverted about cold, with what other looſe papers, touching that quality, I could not ſo readily diſpatch to the preſs; and would not withhold from the curious what aſſiſtance my collections could afford them, to make uſe of this winter to proſecute experiments of cold. And remembering how favourable an entertainment my former endeavours to gratify ingenious men had found among them, I took a courſe, wherein I was more likely to obtain thanks than praiſes, and choſe rather to adventure on the equity and favour of the reader, for the pardon of thoſe faults and imperfections, that are imputable to haſte, than to deny him the opportunity of this cold ſeaſon, wherein to examine the truth, and ſupply the deficiencies of what I had delivered. And this I the rather did, both becauſe I was deſirous to quit this ſubject for another, from which it had diverted me, and for which I have more value and kindneſs; and becauſe, that as a tender conſtitution of body kept me, whilſt I was writing the following hiſtory, from adventuring upon ſome trials, that might (probably) have enriched it; ſo the continuance of the ſame diſadvantages, together with other inopportune diſtempers ſuperadded to them, do not permit me to know, whether, and how far I ſhall be able to proſecute the work I have begun; and do oftentimes reduce me to be more concerned to ſhun the effects of cold, than obſerve the phænomena of it. And indeed, whether thoſe prove true prophets or no, that aſſure me I ſhall loſe no reputation by this hiſtory (as incompleat as it comes forth,) I think, if ingenious men knew, how much trouble and exerciſe of my patience it has coſt me, they would, peradventure, vouchſafe me ſome of their thanks, if not for what I have done, yet for what I have ſuffered for their ſakes, (and would ſcarce have undergone upon any inferiour account whatſoever;) it being, though a leſs noble, yet no leſs troubleſome an imployment, to dig in mines of copper, than in thoſe of gold; and men being oftentimes obliged to ſuffer as much wet and cold, and dive as deep, to fetch up ſponges, as to fetch up pearls.

New THERMOMETRICAL EXPERIMENTS *and* THOUGHTS.

DISCOURSE I.

Propoſing the firſt Paradox, *viz. That not only our Senſes, but common Weather-glaſſes, may miſinform us about Cold.*

IT may to moſt men appear a work of needleſs curioſity, or ſuperfluous diligence, to examine ſollicitouſly, by what criterion or way of eſtimate the coldneſs of bodies, and the degrees of it are to be judged; ſince coldneſs being a tactile quality, it ſeems impertinent to ſeek for any other judges of it than the organs of that ſenſe, whoſe proper object it is. And accordingly, thoſe great philoſophers, *Democritus*, *Epicurus*, *Ariſtotle*, and (till of late) all others both ancient and modern, ſeem to have contented themſelves in the matter with the reports of their ſenſories.

BUT this notwithſtanding, ſince we can ſcarce imploy too much care and diligence in the examining of thoſe touchſtones, which we are to examine many other things by, perhaps it will be neither unſeaſonable nor uſeleſs to premiſe ſomething touching this ſubject.

FOR though it be true, that cold in its primary and moſt obvious notion be a thing relative to our organs of feeling, yet ſince it has alſo notable operations on divers other bodies beſides ours; and ſince ſome of them ſeem more ſenſible of its changes, and others are leſs uncertainly affected by them, it would be expedient to take in the effects of cold upon other bodies, in the eſtimates we make of the degrees of it.

AND to make this appear the more reaſonable, I ſhall not ſcruple to propoſe the following paradox; namely, That our ſenſories, either alone, or aſſiſted by common weather-glaſſes, are not too confidently to be relied on in the judging of the degrees of cold.

To make this paradox plauſible (which is almoſt as much as I here pretend to) I ſhall repreſent in the firſt place, that the account, upon which we are wont to judge a body to be cold, ſeems to be, that we feel its particles leſs vehemently agitated than thoſe of our fingers, or other parts of the organ of touching. And conſequently, if the temper of that organ be changed, the object will appear more or leſs cold to us, though it ſelf continue of one and the ſame temper.

THIS

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THIS may be exemplified by what has been obſerved by thoſe, that frequent baths, where the milder degrees of heat, that are uſed to prepare thoſe, that come in for the higher, ſeem very great to them, that coming out of the cold air, diſpoſe themſelves to go into the hot baths, but are thought cold and chilling to the ſame perſons, when they return thither out of much warmer places; which need not to be wondered at, ſince thoſe, that come out of the cold air, find that of the moderately warm room more agitated, than the cold ambient would ſuffer the external parts of their bodies to be; whereas the ſame warm air, having yet a leſs agitation than that, in which the hotter parts of the bath had put the ſenſitive parts of the bathers bodies, muſt ſeem cold and chilling to them.

BUT it is not only in ſuch caſes as this, wherein men can ſcarce avoid taking notice of a manifeſt change in themſelves, that theſe miſtaken reports of our ſenſes may have place. For oft-times we are impoſed upon by more ſecret changes in the diſpoſition of our ſenſories, when there needs ſomething of attention and of reaſoning, if not of philoſophy, to make us aware of them. For being apt to take it for granted, that our temper is the ſame, when there is no very manifeſt cauſe, why it ſhould be changed, we often impute that to objects, whereof the cauſe is in our ſelves; and if this change in our ſelves be wrought by unſuſpected agents, or by inſenſible degrees, we do not eaſily take notice of it. Thus though in ſummer divers cellars, that are not deep, are perhaps no colder than the external air was, (when it was judged but temperate,) in winter or the ſpring; yet it will ſeem very cold to us, that bring into it bodies heated by the ſummer ſun, and accuſtomed to a warmer air; nay, cold does ſo much depend upon the degree of agitation in the parts of the object, in reference to the ſentient, that even when we may think the ſenſory unaltered, it may judge an object to have a degree of coldneſs which indeed it hath not; as I remember, that to ſatisfy ſome friends, that it is not every wind, which feels cold to us, that is really more cold than the ſtill air, I have ſometimes ſhewn, that in not nice weather-glaſſes, air blown out of a pair of bellows does not appear to have acquired any coldneſs by being turned into wind, though if it were blown againſt the hands or face, it would produce a new and manifeſt ſenſe of cold: of which the reaſon ſeems to be, that though the organ in general ſeems not to be altered, yet the wind, by reaſon of its motion, is able not only to drive away the parts of the air contiguous to the hand or face, and the warm ſteams of the body, which tempered its coldneſs; but to pierce deeper than the calm air is wont to do into the pores of the ſkin, where, by compariſon to the more inward and hotter parts of the ſenſory, it muſt needs appear leſs agitated and conſequently colder.

BESIDES that ſometimes we may meet with certain ſteams in the air, that have in reference to the blood and ſpirits of human bodies (though not perhaps to divers other liquors) a certain hidden power of chilling, as opium, even in outward applications, (for in ſuch ways I have known a great ſurgeon much uſe it and highly extol it) ſtrikes a coldneſs into the body by the ſubtile effluviums, that inſinuate themſelves at the pores of the ſkin; and perhaps too that coldneſs is aſcribed to external bodies, which is produced in us by ſome frigorifick vapour, or other diſtemper: which being too ſlight to be taken notice of as a diſeaſe, may yet be of kin to thoſe agents, that produce what phyſicians call horrours and rigours at the beginning of fevers, and ſome other diſtempers; or produce that ſtrange and univerſal coldneſs of the external parts, which is frequently enough obſerved among other ſymptoms in hyſterical women. Moreover, bodies may often appear colder to us than to a weather-glaſs, becauſe our ſenſories are more affected by the denſity and penetrancy of the parts. This may ſeem ſomewhat ſtrange, but being ſuitable enough to ſome of my conjectures about cold, I have often made trials with very nice weather-glaſſes, that have aſſured me, that (at leaſt oft-times) when water ſeems to be cold enough to our touch, it appears not to be colder to the weather-glaſs than the ambient air.

THESE trials I have ſometimes made with ſealed weather-glaſſes, but the moſt with another ſort of weather-glaſſes (whoſe ſtructure and uſe are by and by to be mentioned) which though they ſeldom prove durable, nor of any great uſe in any other than ſuch nice and ſhort experiments, yet they diſcover ſlighter changes of the temper of the air, than would be notable (not to ſay ſenſible) in ordinary thermometers. But of multitudes of trials, that I ſometimes made with theſe glaſſes, I can at preſent find among my looſe papers but a very few; and though I remember, that in one or two (made about the ſame time with ſome of thoſe that follow) I obſerved things, that make me now wiſh I had had opportunity to make thoſe further trials of them, which ſome of their phænomena ſeem to direct the making of; yet I ſhall annex theſe that follow, as I find them entered, becauſe they are not perhaps deſtitute of hints improveable by further proſecution. *June* 26. between two and four in the afternoon (the weather moderate for the ſeaſon) I took a thin white glaſs-egg blown at a lamp about the bigneſs of a walnut, with a ſtem coming out of it about the bigneſs of a large pigeon's quill four or five inches long, and open at the top; this ſlender pipe being dipped in water, admitted into its cavity a little cylinder of water, of half an inch long or ſomewhat more, which (the glaſs being erected) ſubſided by its own weight, or the temper of the air in the egg (in reference to the outward air) till it fell to the lower part of the pipe, where it comes out of the egg, and thereabout it would reſt. Now if taking this glaſs by the top betwixt my thumb and forefinger, I depreſt the egg under the ſurface of a baſon of fair water (cold enough to the touch) the little aqueous cylinder, that parted betwixt the air in the egg, and the external, would, inſtead of being made to ſubſide by the egg's immer-

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ſion into cold water, preſently riſe up from the lower part of the pipe, till it reached about the middle of it, though the glaſs were, in this and the following trials, held erected; and as ſoon as it was taken out of the water into the air, the water would again ſubſide, whether I held the glaſs, or let it reſt upon the boards, or a linnen carpet, that covered the tables, on which the trials were made. And this I did ſeveral times as well with as without witneſs. I tried alſo that if, inſtead of water, I made uſe of quickſilver, though not big enough to cover the egg much above half way, and in the reſt proceeded as above; the cold quickſilver would preſently make the aqueous cylinder haſtily aſcend near three inches, ſometimes almoſt, and ſometimes quite to the top of the ſlender pipe, whence the water would again quickly ſubſide, when the glaſs was taken out into the free air, or ſet to reſt upright as before.

BESIDES, having ſet the veſſel of quickſilver and the baſon of water very near one another, I did at leaſt upon three or four ſeveral trials find, as I expected, that when by immerſing the egg in water, the pendulous cylinder was raiſed ſo high, that it did no longer ſenſibly aſcend, by nimbly taking the egg out of the water and depreſſing it in the quickſilver, it would riſe far higher: and I alſo tried, that nimbly removing the egg out of the quickſilver into the water, the pendulous cylinder would ſubſide, after plunging the egg under water, though not ſo faſt, nor near ſo low, as it would do, in caſe the glaſs were removed from the quickſilver into the air. Upon another trial made much about this time, though not the ſelf-ſame day; the pendulous water in the ſame glaſs, (the day being for the moſt part windy and rainy) did ſubſide upon the immerſion of the glaſs into water, not only a while before noon, but an hour or two after dinner, and at diſtant hours afterwards, though the deſcent of the pendulous water was neither quick, nor ſo conſiderable, as it had been formerly in the mornings.

June 27. IN the morning a ſmall cylinder of water pendulous in the above mentioned glaſs, upon the immerſion of the egg in a baſon of water, would immediately and very conſiderably ſubſide; whereas the ſame glaſs, being immerſed in the veſſel of quickſilver formerly mentioned would preſently aſcend. Both parts of this experiment we ſeveral times tried, and the reaſon was ſuſpected to be, that the quickſilver had ſtaid all night in my chamber, which was ſomewhat warm, whereas the water was brought up that morning, and to the touch ſeemed colder than the quickſilver; and a while after dinner, the ſame water having been ſtill kept in the room, we divers times found, that as well that, as the quickſilver, did immediately, upon immerſion, impell up the pendulous water in the ſlender pipe. Another time in the froſty weather (and about the beginning of *January*) we did with ſuch a glaſs (as has been already ſeveral times mentioned) take ſome drops of water out of a veſſel, wherein that liquor had for a good while been kept; that it might be reduced as near as we could to the temperature of the ambient air; then ſuffering the ſuſpended water to continue a convenient while in the long and ſlender ſtem of the weather-glaſs, that the internal air might be reduced to the temper of the external, we took up the glaſs by the open end; and immerſing the obtuſe part of it into a ſhallow veſſel, containing ſome of the above mentioned water, we found the ſuſpended drop ſuddenly impelled upwards about half an inch or more, and the ball of the thermometer being taken out of the water into the air, the pendulous drop did again (though far more ſlowly than it aſcended) ſubſide. This was repeated three or four times with ſome intervals between (and that in a room where there was no chimney) and ſtill with the like ſucceſs, ſave that in the two laſt trials we took the weather-glaſs out of the ſhallow water, and plunging it into a deep veſſel of the ſame water (that ſtood very near the other) we found (for further confirmation of the experiment) that the pendulous water was, upon theſe new immerſions, impelled up, near (if not full) as high again, as when we had immerſed it only in the ſhallow veſſel: and taking it out of this deep glaſs, we found the cold of the external air to reduce it to its former humble ſtation. Thus far the notes, I have yet been able to recover: and though, as I ſaid, I dare not build very much upon them, yet by ſmall ſealed weather-glaſſes I find enough to invite me to ſuſpect, that of the degrees of heat and cold in the air we may receive differing informations, when we imploy only our organs of touching, and when we make uſe of fit inſtruments.

I SHALL add on this occaſion, that not only water it ſelf, but moiſt vapours abounding in the air, may make us think it colder than the weather-glaſs diſcovers it to be. For though it be generally taken for granted, that the thermometer does only more exactly meaſure or determine the effects, which cold hath both upon it and upon our ſenſories; yet I have long ſuſpected there is ſomewhat elſe in the caſe, and I have obſerved, that ſometimes the weather ſeemed more or leſs cold to me, than that which preceded, when the contrary appeared in the weather-glaſs; and that, when upon conſideration of the whole matter, that difference did not appear to depend upon thoſe circumſtances of exerciſe or reſt, or the temperature of the air I came out of, or any of thoſe other things, to which a conſiderate man, that goes upon no better than the common opinions about weather-glaſſes, would be apt to impute to that phænomenon. And I was the leſs diſpoſed to think my ſelf miſtaken, becauſe having purpoſely enquired of others in the ſame houſe, who were not told, what information the weather-glaſs gave, they agreed with me in the ſenſe I had of the temperature of the weather. And having ſince, as occaſion ſerved, communicated my obſervations and ſuſpicions to divers ingenious men, I have been by their recenter obſervations confirmed, that what I have taken notice of, was not the effect of any Ἰδιοσυγκρασία. From which and other particulars, that we may have elſewhere opportunity to mention, we may plauſibly enough infer, that

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it were not amiſs, not only to take notice, when we have opportunity, of the ſenſe, that is expreſſed of the degrees of cold by birds and other animals, whoſe diet is more ſimple and regular than ours, and whoſe perceptions are commonly more delicate and leſs diverted; but eſpecially, to examine the coldneſs of the air and other bodies as well by experiments and inſtruments, as by the touch. And on this occaſion I muſt not pretermit that memorable account, that is given us by *Martinius*, in that noble piece of geography, which he calls *Atlas Chinenſis*, where ſpeaking of the air of that populous country, he has this ſingular paſſage: *Ad cæli* (ſays he) *ſolique temperiem quod attinet, majus in hac provinciâ frigus eſt, quàm illius poſcat poli altitudo; vix enim illa excedit gradum ſecundum ſupra quadrageſimum; & tamen per integros quatuor ſæpe menſes flumina omnia adeò durè concreſcunt gelu, ut currus equoſque ac graviſſima etiam onera glacies ferat, innoxiè ac ſecuriſſimè tranſeant: ex iis ingentia etiam glaciei fruſta exſcinduntur, quæ in futuram æſtatem ad delicias ſervant. His menſibus omnes naves ita in ipſâ glacie defixæ ſunt, ut progredi nequeant ubicunque illas frigus occupat (quod certo certius circa medium Novembris ingruere ſolet) per quatuor illos menſes immotæ ibi perſtare coguntur, neque enim reſolvitur glacies ante Martii initium; hæc plerumque glaciei concretio uno fit die, cum non niſi pluribus fiat liquefactio.* To which he adds, what makes moſt to our preſent purpoſe, *omnino illud mirum, tantum non videri aut ſentiri illud frigus, ut Europæos ad hypocauſta ſubeunda videatur poſſe cogere, aut in Europâ ad glaciem producendam ſufficere, unde ad ſubterraneas illic exhalationes pro harum rerum cauſis indagandis omnino recurrendum eſt*, &c.

BUT all that I have been implying of the neceſſity and uſefulneſs of the weather-glaſs, is no ways inconſiſtent with the truth of the latter part of our formerly propoſed paradox; namely, that we are not raſhly to rely upon the informations even of common weather-glaſſes themſelves. For though they be an excellent invention, and their informations, in many caſes, preferable to thoſe of our ſenſes, becauſe thoſe dead engines are not, in ſuch caſes, obnoxious to the ſame cauſes of uncertainty with our living bodies; yet I fear they have too much aſcribed to them, when they are looked upon as ſuch exact inſtruments to meaſure heat and cold by, that we neither can have, nor need deſire any better. For, not yet to mention ſome inconveniencies in the contrivance of them, which makes them unapplicable to ſome purpoſes, and leſs proper in others, than thermoſcopes might be made, even in divers caſes, wherein they are preſumed to be unexceptionable, their reports are not to me, I confeſs, quite exempt from ſuſpicion. For, in ordinary weather-glaſſes, ſome part of the liquor being contiguous to the external air, it is ſubject to be impelled more or leſs upwards, not only according as heat or cold affects the included air, but according as the incumbent air happens to be heavier or lighter. And though this be a thing not taken notice of by thoſe, that have treated of weather-glaſſes, yet after what we have elſewhere manifeſted concerning the weight and ſpring of the air, and what we have probably conjectured concerning the varying height of the mercurial cylinder in the Torricellian experiment; I ſee not why it ſhould not much call in queſtion the informations we receive from common weather-glaſſes in thoſe caſes, where the height or weight of the atmoſpherical pillar, that preſſes upon the water in the weather-glaſs, is conſiderably longer or ſhorter, lighter or heavier than is uſual. *See the 1 Sect. of our* New Phyſico-Mechanical Experiments.

FOR beſides the reaſon of the thing, we have experience on our ſide. I might mention, on this occaſion, an experiment I thought on, and alſo attempted, laſt winter, to ſhow, even upon a ballance, the varying gravity of the atmoſphere in one and the ſame place, by hanging a ſmall metalline weight at one end of a pair of ſcales ſo ſtrangely exact, that they would turn with far leſs than the five hundredth part of a grain; and counterpoiſing it at the other end with a hermetically ſealed glaſs bubble, which being blown as large and as thin as could poſſibly be procured of ſo ſmall a weight, might, by its great diſproportion in bulk to the metalline body, loſe more of its weight than that would upon the ambient air's growing more heavy. But the particular account of this attempt belonging to another place, the trial ought not to be more than hinted here; eſpecially ſince it may ſuffice for our preſent purpoſe to alledge, that having found (as we have already in other papers noted) that in a weather-glaſs, where the water is not fenced from the external air, the weight of the atmoſphere may make it alter conſiderably between the top and the bottom even of a church or ſteeple, though it appeared by more certain thermoſcopes, that it was not the differing temperature of the air, as to cold and heat, but the differing gravity of the atmoſphere, which being ſhorter and lighter at the top, preſſed leſs forcibly upon the ſubjacent water and the included air, as is more fully made out in the treatiſe above related to. And having, by the the intervention of a learned acquaintance, deſired to have ſome experiments made of the effect of the air upon weather-glaſſes in deep pits or mines, where the atmoſpherical cylinder is longer and heavier, I received information, that an ingenious phyſician, (Dr. *H. P.*) who had the opportunity of trying what I deſired, had found, that in the bottom of one of thoſe very deep pits, the water, in a common weather-glaſs, roſe near three inches higher than at the top, in a ſhank or pipe of about thirty inches long. And this notwithſtanding the warmth, that is uſual in ſuch deep places, which ſeems not any thing near ſo plauſibly referrible to any other cauſe, as to the increaſed gravity of the atmoſpherical pillar incumbent on the water, that pillar being heavier at the bottom than at the mouth of the pit, by the weight of an aërial pillar equal in length to the pit's perpendicular height or depth. *In the Defence againſt* Linus, *chap.* 4.

BUT theſe are not the only caſes, wherein the differing gravities of the atmoſphere may, as well

well as heat and cold, have an intereſt in the riſing and falling of the liquor in common weather-glaſſes. For though you ſhould not remove them out of one place; and though conſequently it may ſeem, that the atmoſpherical pillar, that preſſes upon the water, muſt be ſtill of the ſame length, yet (not to urge, that that may alter unknown to us) if retaining its length it retain not its gravity, we may be eaſily impoſed upon, and take that aſcenſion or ſubſidence of the liquor for the effect of a higher or remiſs degree of cold, which may either totally or at leaſt in part (and in what part, we are left to gueſs) be the effect of the increaſed or leſſened weight of the atmoſpherical pillar, happening either by the copious diſperſion of vapours and other heavy ſteams through the air, or upon other occaſions not neceſſary to be here diſcourſed of, or by the precipitation of ſuch vapours by rain, or into dew, or elſe by the removal of the occaſions of the augmented gravity or preſſure of the air. For we have often obſerved great variations to happen in the height of the mercurial cylinder, in the Torricellian experiment, upon great rains and fogs, and other ſudden and conſiderable mutations of the incumbent air. But ſince I myſelf thought fit, notwithſtanding the plauſible ratiocination, that led me to this conjecture, to examine it by experience; I can ſcarce doubt, but that others may have the like curioſity that I had. And therefore, becauſe it may ſeem a paradox, it will not be amiſs, of many to annex three or four trials I made to examine the propoſed doctrine, eſpecially ours having been the firſt obſervations of this kind, that, for aught we know, have been made by any. And indeed others could ſcarce have well made much, though they lighted on the ſame thoughts, for want of ſuch ſealed weather-glaſſes to make them with. To omit then thoſe, that I made with a ſealed weather-glaſs, and an ordinary one (in which the water remains ſuſpended beneath the included air) I ſhall briefly relate, that in a room unfurniſhed with a chimney, I kept two weather-glaſſes, which, for more exactneſs ſake, I cauſed to be made of a length far greater than ordinary; ſo that the diviſions of the one were half inches, and thoſe of the other not much leſs, and yet were numerous. The one of theſe, which was furniſhed with good ſpirits of wine, was ſealed, the other not; but this laſt I cauſed to be ſo made of the ſhape repreſented by the ſcheme, that the air being ſhut up in the lower part of the inſtrument (not as in common weather-glaſſes at the top) the liquor might as well in this, as in the ſealed weather-glaſs, riſe with heat and fall with cold. In theſe thermoſcopes (where the aſcenſion and relapſe of the liquors were, by reaſon of the length of the pipes, far more conſpicuous than in vulgar weather-glaſſes) I obſerved, with pleaſure, that the hermetical thermoſcope (if I may for diſtinction-ſake ſo call it, by reaſon of its being hermetically ſealed) did regularly enough deſcend in cold weather, and aſcend in warm: but the other, which was not ſealed, but had a little hole left open at the top of the pipe, though, when the atmoſphere continued of the ſame weight, it would, like the other, riſe with heat and fall with cold, yet when the atmoſphere's gravity was altered, they would not uniformly move together, but when (as we gathered from other obſervations) the atmoſphere grew heavier, the liquor in the pipe did not aſcend, as high as it would have done, if the atmoſphere had continued in its former degree of gravitation. And, on the contrary, when the incumbent air came to be lighter, the liquor would riſe in the open weather-glaſs in a proportion greater than the ſingle increaſe of heat would have exacted; ſo that by comparing the two weather-glaſſes together, I did uſually foretel, whether the mercury in the Torricellian tube (which I keep purpoſely by me in a frame) were riſen or fallen, and conſequently whether the external air were heavier or lighter than before: As, on the other ſide, by looking on the height of the mercurial cylinder, I could eaſily tell before-hand, whether the liquor in the open weather-glaſs were higher or lower than that in the hermetical; the riſing or falling of the mercurial cylinder one quarter of an inch (the temperature of the air continuing as to heat and cold) uſually ſignifying a great diſparity betwixt the aſcenſion or the falling of the liquors in the two inſtruments.

AMONG the ſeveral notes, I find among my looſe papers, and in a diary I kept for a while of theſe obſervations, I ſhall content my ſelf to tranſcribe the following two, becauſe, though divers others were made by my Amanuenſis, whoſe care is not to be diſtruſted, yet by reaſon of my abſence I could not take notice of them my ſelf. The firſt of theſe *Memorandums* runs thus.

LAST night I took notice, that there was but one or two diviſions difference betwixt the two thermometers, but upon ſuch a change of weather, that happened this day, as made me imagine, that the atmoſphere would be lighter than before, conſulting the barometer (if to avoid circumlocutions, I may ſo call the whole inſtrument wherein a mercurial cylinder of 29 or 30 inches is kept ſuſpended after the manner of the Torricellian experiment;) I found the quickſilver lower than it had been a great while, and thereupon concluding, there would be a notable diſparity, between the ſealed and open weather-glaſs, I haſted to them, and found that the latter being much alleviated from the weight of the incumbent air, was no leſs than 17 diviſions higher than the others; and comparing the height the two inſtruments were this day at, with an obſervation I my ſelf made about a week ago, when the quickſilver was much higher than now it is; I found, that although this afternoon the ſealed glaſs being at 41, the other was 58, yet then, when the ſealed weather-glaſs was five diviſions higher, namely, at 46, the unſealed weather-glaſs was but at 27. So that betwixt that time and this, the liquor in the ſealed weather-glaſs, has deſcended five diviſions, but that in the open weather-glaſs has aſcended 31.

THUS far the firſt of the above mentioned notes; the ſecond is as follows.

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THE mercurial cylinder being higher, than it has been a good while, and yet the weather warm and ſun-ſhiny, when the liquor in the ſealed glaſs ſtood very near the 50th diviſion, that in the unſealed was fallen down as low as the 32d.

So that it is very poſſible, that the unheeded change in the weight of the external air may have a greater power to compreſs the included the air in an unſealed weather-glaſs, than a not inconſiderable degree of warmth may have to dilate it; and conſequently in an ordinary weather-glaſs, where the air is included at the top, it may often fall out, that contrary to what men ſuppoſe muſt needs happen, the pendulous water may riſe in warmer weather and fall in colder.

AND even ſince the writing of the immediately foregoing part of this page, within a few days that intervened, I have my ſelf made obſervations, that do yet more clearly manifeſt this truth, as may appear by the following notes. The firſt of which ſpeaks thus.

Memorandum, THAT yeſterday night the quickſilver being at 29 inches, the liquors in the ſealed and unſealed weather-glaſſes were near about the ſame diviſion, the former being at 40, and the other being but half a diviſion ſhort of that number. But this night the quickſilver being riſen about $\frac{1}{4}$ of an inch; the liquor in the ſealed is aſcended to 45, and the other deſcended beneath 35 about half a diviſion, ſo that there are now 10 diviſions tween them.

THIS the firſt note, to which the following night enabled me to add this other.

THE quickſilver being riſen almoſt $\frac{3}{4}$ of an inch above the ſtation it reſted at, the night before laſt night, the hermetical weather-glaſs being as it was then above the 40th diviſion; the liquor in the other, which was open, in two days and nights is fallen to the 17th, and conſequently is ſubſided about 23 diviſions, whilſt the other is about the ſame height, at which it was at the beginning of that time.

TWO or three days after, being returned to the place, wherein I had made this laſt obſervation, and from which ſome urgent occaſions had for that time exacted my abſence; I found the diſparity betwixt the two thermometers, that is expreſſed in the following memorial.

THIS day the quickſilver being riſen to 30 inches, when the liquor in the ſealed weather-glaſs was at about 41 diviſions, that in the other was depreſſed a pretty deal below the 9th diviſion; ſo that the difference between the two thermometers was increaſed ſince the laſt obſervation from 23 near to 33 diviſions, all which the liquor in the open weather-glaſs had ſunk down, whilſt that in the ſealed continued almoſt at a ſtand. And the day after this memorial, I had occaſion to regiſter another, which being the laſt, I ſhall here think requiſite to take notice of in this diſcourſe, I ſhall ſubjoin it with that, which immediately preceded in order of time.

THIS day the quickſilver continuing at the ſame height, at which I obſerved it yeſterday, but the weather being grown much colder, the liquor appears in both the glaſſes to have uniformly enough ſubſided; that in the ſealed weather-glaſs being about the 33d, and the other being ſunk quite below the loweſt mark of all, which was more than I apprehended it would have done, when there was no froſt: eſpecially ſince by my diary it appears, that one of the laſt times I obſerved the hermetical weather-glaſs to ſtand at near about the ſame height, namely, the 34th; the liquor in the other glaſs was no lower than 41: nor probably would there be now ſo great a difference, if the atmoſphere had not been this day very heavy; whereas, when this freſhly-recited obſervation was made, I find by the diary, the quickſilver to have aſcended but to 29 inches, and a pretty deal leſs than a half.

SINCE that time, being forced by ſeveral avocations to be often abſent from the place where my thermoſcopes were kept, I was not careful to proſecute ſuch obſervations, thoſe already ſet down (not to mention thoſe, that are not here tranſcribed) being judged abundantly ſufficient to evince the paradox propoſed to be proved by them: only to manifeſt, that after I deſiſted from regiſtering my obſervations, the phænomena may probably have been as remarkable as before; I ſhall add, that one of the laſt times I chanced to take notice of the difference to be gathered by comparing the two weather-glaſſes, I found (the weather happening to be warmer than ordinary) the difference between them to exceed any, that I remembered my ſelf to have then obſerved, amounting to 44, if not to 45 diviſions.

AND even ſince the writing of the laſt line, we have had opportunity to obſerve a phænomenon, which if it had occurred to us in the place, where we might have compared the baroſcope with the exact weather-glaſſes hitherto mentioned, (and whereby we had been invited to rely upon it) would perhaps appear more conſiderable, than any of the obſervations yet recorded. For not very many hours ago, finding in the morning the quickſilver to be riſen in a good baroſcope of mine (though another from that, all this while referred to, and elſewhere kept) above $\frac{3}{4}$ of an inch higher than the place it reſted at the night foregoing, and a ſomewhat nice weather-glaſs (where the included air is kept in the lower part of the inſtrument, which is ſhaped like that already deſcribed in this diſcourſe) being conſulted to ſhow, what effect ſo great and ſudden a change of the atmoſphere's gravity would have upon it; I ſaw the tincted liquor in the ſhank depreſſed a full inch or more beneath the ſurface of the ambient liquor in the phial, which ſtrange depreſſion of the liquor in a pipe above 20 inches long, and where the alterations of the air as to heat and cold are not wont to produce any thing near ſo great an effect, I could not but take much notice of. Since the ſeaſon of the year makes it no way likely, that the night, though cold, could have had ſo powerful an operation on it, eſpecially ſince an amanuenſis, that watched it muchlonger than I, affirms, that he ſaw the liquor driven down quite to the very bottom of the pipe, and a bubble of the outward air to make its paſſage through the water, and to join with the air contained in the cavity of the phial.

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DISCOURSE II.

Containing ſome new Obſervations about the Deficiencies of WEATHER-GLASSES, *together with ſome Conſiderations touching the New or Hermetical Thermometers.*

AND ſince I had occaſion to ſpeak of the deficiencies of weather-glaſſes, and the miſtakes, whereto men are liable in the judgment they make of cold and heat upon their informations, it will not perhaps appear impertinent to add three or four conſiderations more, to excite men to the greater warineſs and induſtry, both in the making and uſing weather-glaſſes, and in their judging by them.

I. AND firſt, I conſider, that we are very much to ſeek for a ſtandard, or certain meaſure of cold, as we have ſettled ſtandards for weight, and magnitude, and time; ſo that when a man mentions an acre, or an ounce, or an hour, they, that hear him, know what he means, and can eaſily exhibit the ſame meaſure: but as for the degrees of cold (as we have elſewhere noted concerning thoſe of heat) we have as yet no certain and practicable way of determining them; for, though, if I uſe a weather-glaſs long, it is eaſy for me to find, when the weather is colder, or when warmer, than it was at the time, when the weather-glaſs was firſt finiſhed; yet that is a way of eſtimating, whereby I may in ſome degrees ſatisfy myſelf, but cannot ſo well inſtruct others, ſince I have no certain way to know determinately, ſo as to be able to communicate my knowledge to a remote correſpondent, what degree of coldneſs or heat there was in the air, when I firſt finiſhed my thermoſcope: for beſides that we want diſtinct names for the ſeveral gradual differences of coldneſs, we have already declared, that our ſenſe of feeling cannot ſafely be relied upon to meaſure them. And as for the weather-glaſs, that is a thing, which, in this caſe, is ſuppoſed to be no fit ſtandard to tell us what was preciſely the temper of the air, when itſelf was firſt finiſhed, ſince that does but inform us of the receſſions from it, or elſe that the air continues in the temper it was in at the making of the inſtrument, but does not determine for us that temper, and enable us to expreſs it; as indeed it is ſo mutable a thing, even in the ſame place, and oft-times in the ſame day, if not the ſame hour, that it ſeems little elſe than a moral impoſſibility, to ſettle ſuch an univerſal and procurable ſtandard of cold, as we have of ſeveral other things. And indeed there is ſcarce any quality, for whoſe differences we have fewer diſtinct names, having ſcarce any for the many degrees of coldneſs, that may be conceived to be intermediate, betwixt lukewarmneſs and the freezing degree of cold, and even theſe are undefin'd enough; for that, which to ſome men's ſenſes will feel lukewarm, by others will be judged hot, and by others, perhaps, cold; nor is even the glaciating degree of coldneſs well determined, ſince not only differing liquors, as oil, wine, and water, will manifeſtly freeze much more eaſily one than another, but even liquors of the ſame denomination; and of waters themſelves, ſome are more eaſily turned into ice than others: and I ſee no great cauſe to doubt, but that there may be ſufficiently differing degrees of cold, whereof the mildeſt may ſuffice for the congelation of ſome waters. I muſt not forget to add, that the ſame perſon, that has made many obſervations with a weather-glaſs, is ſo confined by that numerical inſtrument, that, if by the ſpilling of the liquor, or the cracking of the glaſs, or the caſual intruſion of ſome bubbles of air, or by any of divers other accidents, that may happen, the inſtrument ſhould be ſpoiled, he would, though he ſhould employ again the ſame inſtrument, be reduced to ſeek out a new ſtandard, wherewith to meaſure the varying temperature of the air. And though it be not difficult to include in the cavity of a weather-glaſs ſome other fluid body inſtead of air, yet it will be very difficult, if not impoſſible, to include a body, fit to reſent and ſhow the alterations of the ambient air, without being alſo liable to receive impreſſions from it at the time of its being firſt ſhut up.

YET I will not here omit, that I have ſometimes conſidered, whether the eſſential oil of aniſeeds (which is that, that is diſtill'd by the intervention of water in a limbeck) might not, during a good part of the year, be of ſome uſe to us, in making and judging of weather-glaſſes. For this liquor, as we elſewhere alſo note, having the peculiarity of loſing its fluidity during almoſt all the winter, and a good part of the ſpring, and autumn too, when the weather, or the time of the day, is colder; this liquor, I ſay, being ſuch, in caſe you very gently thaw it, and then putting into it the ball of a weather-glaſs, furniſhed with ſpirit of wine, that will burn all away, you ſuffer the oil to re-congeal leiſurely of itſelf, you may, by obſerving the ſtation of the ſpirit of wine in the thermoſcope, when the oil begins manifeſtly to curdle about it, be in ſome meaſure aſſiſted to make another weather-glaſs like it*. For if you put ſuch rectified ſpirit of wine into a glaſs, the cavity of whoſe ſpherical, and that of its cylindrical part, are as near, as may be, equal to the correſpondent cavities in the former glaſs, you may, by ſome heedful trials made with thawed and recongealed oil of aniſeeds,

* An ingenious man has propoſed another way of ſettling a ſtandard for weather-glaſſes, namely, by obſerving the coldneſs, which is requiſite to make diſtill'd water begin to freeze: but though the accurateneſs of this way may be as well as the other juſtly queſtioned, and cannot often be put in practice, even in winter itſelf, nor without trouble; yet it may alſo be advantagiouſly made uſe of, when the cold happens to be great enough to freeze water.

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ſeeds, bring the ſecond weather-glaſs to be ſomewhat like the firſt; and if you know the quantity of your ſpirit of wine, you may eaſily enough make an eſtimate, by the place it reaches to in the neck of the inſtrument, whoſe capacity you alſo know, whether it expands or contracts itſelf to the 40th, the 30th, or the 20th part, *&c.* of the bulk it was of, when the weather-glaſs was made. By the help of the ſame oil you may make ſome kind of eſtimate, though a more uncertain one of the difference of two weather-glaſſes of unequal bigneſs: and though I know not how much may be alledged to ſhew the uncertainty of this way of making a ſtandard for weather-glaſſes; yet as what I have formerly repreſented may manifeſt me to be far enough from looking on it as an exact ſtandard of cold; ſo perhaps the way propoſed may not be altogether uſeleſs in the making and comparing weather-glaſſes, ſince, in ſuch caſes, where we are not to expect to hit the mark itſelf, it is of ſome advantage to be able to ſhoot leſs wide of it, than otherwiſe we ſhould.

II. BUT not to inſiſt any further on a difficulty, which is ſo hardly evitable as that, which occurs about ſettling a perfect ſtandard of cold, there are unaccurateneſſes in the meaſuring of cold by weather-glaſſes, which may be avoided, but are not; for men are not wont to take care, that the ſtems be even and cylindrical enough, but are wont to make uſe of ſuch, as are much wider at the upper part near the bubble, than otherwhere; nor do they obſerve, as they might, a proportion betwixt the diameter of the bore of the cylinder, and that of the cavity of the ſpherical bubble, and divers other circumſtances are commonly neglected, which, if well ordered, would make much towards the certainty and inſtructiveneſs of the informations, afforded us by weather-glaſſes. To which may be added, that even in thoſe, where ſome part of the liquor is expoſed to the external air, there may be made contrivances much more convenient, in order, at leaſt, to ſome particular purpoſes, than that of the vulgar weather-glaſs; ſome of which we have imployed, and others have been either ſkilfully deviſed, or alſo happily attempted by ſome eminently ingenious members of the Royal Society. And though that, which we have already deſcribed in another treatiſe, be very ſimple, yet it is much more commodious for ſeveral of the following experiments of cold, than that, which is commonly in uſe. For in this, where the included air is as it were pendulous at the top of the glaſs, it is very troubleſome and difficult ſo to apply cold bodies, and eſpecially liquid ones to it, as therewith to meaſure their temper; whereas the thermometers, I ſpeak of, being made by the inſertion of a cylindrical pipe of glaſs (open at both ends) into a phial or bottle, and by exactly ſtopping with ſealing-wax, or very cloſe cement, the mouth of the phial, that the included air may have no communication with the external, but by the newly-mentioned pipe: in this kind of inſtrument, I ſay, by chuſing a phial as large as you pleaſe, and fitting it with a cylinder, ſlender enough, the proportion between the part of the phial poſſeſt by the included air, and the cavity of the cylinder, in which the liquor is to play up and down, may be eaſily made ſo great, as to make the liquor in this inſtrument, with the ſame degree of heat and cold, riſe or fall four or five, or more times, as much as the pendulous liquor is wont to do in an ordinary weather-glaſs, where the cavity that lodges the air, is wont to be much too ſmall, conſidering the bigneſs of the pipe, whereinto the air muſt, when it is rarified, expand itſelf. But it is not the greater ſenſibility (if I may ſo ſpeak) of this very kind of weather-glaſſes, nor their not needing frames, that makes me take notice of them in this place, (where I purpoſely paſs by contrivances that I know to be more curious) but this other quality, which makes them fit for divers of the following experiments, wherein we ſhall have occaſion to mention them; namely, that with little or no trouble and inconvenience we may imploy liquors or other bodies to refrigerate the included air, by immerſing the phial, if need be (by a weight) into the liquor to be examined, and letting it ſtand there as long as we pleaſe. And ſo we may alſo meaſure the coldneſs of earth, ſnow, powdered ice, and other conſiſtent bodies, which may be heaped about the phial, or in which it may be buried.

III. I CONSIDER too, that though men are wont confidently enough to conclude, that in caſe (for inſtance) the coldneſs of the weather make the liquor in a thermoſcope yeſterday an inch higher than it was the day before, and this day an inch higher than it was yeſterday, the air muſt be this day as cold again as it was yeſterday, or at leaſt that the increaſe of cold muſt be double to what it was yeſterday, and ſo in other proportions; yet the validity of this collection may very juſtly be queſtioned; for, though we ſhould grant, that cold is that, which of itſelf, or by its own power, contracts the air, yet how does it appear, that a double degree of cold muſt produce a double degree of condenſation in the air, and not either more or leſs? Since beſides that it is taken for granted, but not proved, that the differing qualities of included air in ſeveral inſtruments, and the differing bigneſſes of the pipes, and the differing degrees of expanſion, wherein the included air may happen to be, when the aſcenſion of the water begins to be reckoned, may render this hypotheſis very ſuſpicious; beſides all this, (I ſay) I am not inclined to grant, (what philoſophers have hitherto ſuppoſed) that the condenſation of the air, and the aſcenſion of the water, is only, or ſo much as principally, collected by the proper virtue of the cold, but by the preſſure of the ambient air, as we ſhall ere long more fully declare. And if this be made out, then the computation, we are conſidering, will be found to be very fallacious; for we have elſewhere ſhewn, *that the ſtrengths required to compreſs air are in reciprocal proportion, or thereabouts, to the ſpaces comprehending the ſame portion of air.* So that if a cylinder (for inſtance) of four inches of air, be

Dr. Wren. *Dr.* Goddard. *Mr.* Hook.

Defence againſt Linus, *chap.* 5.

be juſt able to reſiſt a ſtrength or preſſure equivalent to ten pound weight, when it comes to be compreſſed into two inches; in this caſe, I ſay, an equal force ſupperadded to the former, (which makes that a double force, or equivalent to twenty pound weight,) will drive up that already-compreſt air into half the ſpace; that is, into one inch or thereabouts. Whence it follows, that in eſtimating the condenſation of the air in a weather-glaſs, we muſt not only conſider, how much ſpace it is made to deſert, but alſo, what proportion that deſerted ſpace bears to the whole ſpace it formerly poſſeſt, and to what degree of denſity it was reduced, before the application of the then force; and we muſt remember, that the reſiſtance of the included air is not to be looked upon, as that of a weight, which may remain always the ſame, but that of a ſpring forcibly bent, and which is increaſed more and more, as it is crouded into leſs and leſs room. But theſe nicer ſpeculations it would here be ſomewhat improper to purſue.

IV. WHEREFORE I ſhall proceed to what may ſeem a paradox, that even the particular nature of the liquors, employed in weather-glaſſes, is not altogether to be neglected, till we have a better and more determinate theory of the cauſes of cold, than I fear we have: for, though uſually it matters not much, what liquor you employ, yet it is not impoſſible, that in ſome caſes men may ſlip into miſtakes about them; for it will not follow, that if of two liquors, the one be much the more obnoxious to the higher degree of cold, that of glaciation, the other muſt be leſs eaſily ſuſceptible of the lower degrees of cold; ſince thoſe, that make ſealed weather-glaſſes, ſome with water, and ſome with ſpirit of wine, have confeſſed to me, that they find theſe (laſt named) much more apt to receive notable impreſſions from faint degrees of cold, than thoſe, that are furniſhed but with water, which yet is eaſily turned into ice by the cold of our climate, which will by no means produce the like effect upon pure ſpirit of wine.

BESIDES, we cannot always ſafely conclude (as philoſophers and chymiſts generally do) that the more ſubtile and ſpirituous liquors muſt be the leaſt capable of being congealed (that is, made to loſe its fluidity, as oil and ſome other ſubſtances are wont to be reduced to do, by the action of cold) for the chymical oil of aniſeeds diſtilled by a limbeck is ſo hot and ſtrong a liquor, that a few drops of it conveniently diſſolved will make a whole cup of beer taſte as ſtrong, and, perhaps, heat the body as much as ſo much wine; and yet this hot and ſubtile liquor I have found upon trial, purpoſely made, to be more eaſily congealable (in the ſenſe freſhly explained) by cold than even common water, and to continue ſo ſeveral days, after a thaw had reſolved the common ice into fluid water again. And I know ſome diſtilled liquors, whoſe component particles are ſo piercing and ſo vehemently agitated, that the tongue cannot ſuffer them, and that they are not perhaps inferiour to moſt chymical oils, nor to aqua fortis it ſelf; and yet theſe may be congealed by far leſs degrees of cold, than ſuch, as would yet prove ineffectual to freeze either the generality of chymical oils, or the generality of ſaline ſpirits.

AND indeed, till we attain to ſome more determinate theory of cold, and come to know more touching its cauſes, than we yet do, I ſee not, why it ſhould be abſurd to ſuſpect, that though there be ſome kind of bodies, which ſeem fitted to produce cold indiſcriminately in the bodies they invade or touch; yet if the refrigeration of a body be but the leſſening of the wonted or former agitation of its parts (from what cauſe ſoever that remiſſneſs proceeds) it ſeems not impoſſible, but that beſides thoſe bodies or corpuſcles, that may be looked upon as the catholick efficients of cold, there may be particular agents, which in reference to this or that particular body may be called frigorifick; though they would not ſo much refrigerate another body, which perhaps would be more eaſily affected, than the former, by other efficients of cold. For we may obſerve, that quickſilver may be congealed by the ſteams of lead, which have not been taken notice of to have any ſuch effect, upon any other fluid body; and yet quickſilver is not to be deprived of its fluidity by ſuch a degree of cold, as would freeze not only water but wine. And by what we have formerly related upon the credit of that great traveller, the Jeſuit *Martinius*, it ſeems, that water it ſelf may in ſome regions be ſo diſpoſed by the conſtitution of the ſoil, that it is ſuſceptible of ſtrange impreſſions of cold in proportion to the effect, which that degree of cold produces there in human bodies. Beſides, opium alſo, of which three or four grains have too oft deſtroyed the heat of the whole maſs of blood in a man's body, though that be a very hot, ſubtile, and ſpirituous liquor, does not ſenſibly refrigerate water, as far as I could obſerve with a good ſealed weather-glaſs, which I put ſometimes in a glaſs of ordinary water, and ſometimes into a glaſs of water of the ſame temper, and (as we gueſſed) of the ſame quantity, wherein opium, enough to kill very many men, was put in thin ſlices, and ſuffered to diſſolve; which ſeems to argue, that as differing liquors have each their peculiar texture, ſo there may be certain bodies, whoſe minute particles by their peculiar ſize, ſhape, and motion, may be qualified to hinder, or at leaſt leſſen, the agitation of the particles of the appropriated liquor, into whoſe pores they inſinuate themſelves; and thereby, according to the lately mentioned ſuppoſition, they may refrigerate that particular liquor, without having the like effect on other liquors, whoſe textures are differing. And I might countenance this by adding, that as fiery and agitated a ſpirit as that of wine, when well dephlegmed, is juſtly thought to be; yet I know more liquors than one, that being mingled with it, will in a trice deprive it of its fluidity; and the like change I have ſometimes made in ſome other liquors alſo. But I muſt not inſiſt on ſuch matters, having mentioned them but only to awaken men's curioſity and circumſpection, and not to build much upon them; which will be eaſily credited,

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credited, if it be remembered, that a little above I my ſelf ſufficiently intimated, that this conjecture ſuppoſes ſomething about the theory of cold, which is not yet ſufficiently cleared. Only, becauſe the former experiments ſhew, that the various agitation of the minute parts of a liquor, whereon its fluidity depends, may be hindered or ſuppreſſed by the intervention of adventitious corpuſcles, but do not clearly ſhew, that the liquor by being deprived of that kind of agitation does actually acquire a coldneſs; I might ſubjoin thus much, that by the addition of a certain ſubſtance (which for juſt reaſons I muſt forbear to deſcribe) that would ſcarce ſenſibly refrigerate common water; I can make a certain (and for aught I know, one only) liquor, that is wont to the touch to be much of the temper of water, to receive a conſiderable degree of coldneſs. This, I ſay, (as ſtrange as it may ſeem) I might here ſubjoin to countenance the conjectures, I have been delivering, and afford ſome new corollaries; but for the reaſon newly intimated I forbear, and the rather, becauſe I think it high time to return thither, whence the conſiderations, I have offered about weather-glaſſes, have made me digreſs.

I WAS going then to take notice, upon the occaſion offered by what I related of the influence of the atmoſphere's gravity upon common weather-glaſſes, of the difference between them and thoſe that are hermetically ſealed. And indeed theſe are in ſome things ſo much more convenient than the others, that (if I be not miſtaken) it has already proved ſomewhat ſerviceable to the inquiſitive, that I have directed the making of the firſt of them, that have been blown in *England*. At the beginning indeed I had difficulty to bring men to believe, there would be a rarefaction and condenſation of a liquor hermetically ſealed up, becauſe of the ſchool-doctrine touching the impoſſibility of a vacuum, and eſpecially, becauſe I had never ſeen any experiment of this kind, nor met with any that had: but after ſome trials, which my conjectures led me to make ſucceſsfully enough, that in hermetically ſealed glaſſes, both air and water might be alternately rarified and condenſed; I found my work much facilitated by the ſight of a ſmall ſealed weather-glaſs, newly brought by an ingenious traveller from *Florence*, where it ſeems ſome of the eminent virtuoſi, that ennobled that fair city, had got the ſtart of us in reducing ſealed glaſſes into a convenient ſhape for thermoſcopes. But ſince that, the invention has in *England* by a dexterous hand, that uſes to make them for me, been improved, and the glaſſes we now uſe are more conveniently ſhaped, and more exact than the pattern, I cauſed the firſt to be made by. But the filling of theſe long ones, that we now uſe, is a work of more niceneſs and difficulty, than they, that have not tried, will be apt to imagine, and therefore may elſewhere deſerve either from our pen, or his, that is moſt verſed in making them, a more particular account of the way of performing it; the advantages of theſe weather-glaſſes being at no hand inconſiderable. For, the weight or preſſure of the atmoſphere (which, as we have noted, may work very much upon others,) their being ſealed defends them from: and by this advantage they may be uſed in the higheſt and in the deepeſt places, with as much certainty as any where elſe. Next, whereas in other thermometers the liquor is very ſubject to be ſpilt, in caſe they be removed from place to place, and, which is worſe, though they be not removed, is ſubject to be preyed upon and waſted by the air, whereby informations of ſuch weather-glaſſes are rendered in tract of time ſomewhat uncertain; in ſealed weather-glaſſes, there is no danger, that liquor ſhould either ſpill or evaporate. And upon the ſame account, theſe have this advantage, that you may ſafely let them down into the ſea, and immerſe them in any liquor, you pleaſe, without excepting the moſt corroſive to examine their coldneſs: not to mention, that inſtead of the coarſer liquors uſed in common weather-glaſſes, which are ſome of them not unapt to freeze, and others unapt enough to comply with the ſlighter alterations of the air, and inſtead of the colourleſs liquor, whether water or no (I know not) uſed in the Florentine weather-glaſs I ſaw, we employ highly rectified ſpirit of wine, whoſe being brought to a lovely red with cochineal, opened by the moſt ſubtile volatile ſpirit of urine, by which means the included liquor is not only very conſpicuous and ſecured from freezing, but ſo ſuſceptible of even the ſlighter impreſſions of external bodies (which would work but faintly on water) that 'tis pleaſant to ſee, how many inches a mild degree of heat will make the tincture aſcend in the very ſlender cylindrical ſtem of one of theſe uſeful inſtruments; of which we have ſpoken the more particularly in this place, becauſe we ſhall have frequent occaſions to mention them in the following papers; and no body as yet, that we know, has written any account of them.

BUT though theſe weather-glaſſes be much more to be relied on, than thoſe, that are commonly in uſe, yet we would have a philoſopher look upon both theſe and our ſenſories, but as inſtruments to be imployed by his reaſon, when he makes his eſtimates of the coldneſs of bodies: and though perhaps it will ſignify nothing in the event, yet I ſee not, why it ſhould miſbecome a naturaliſt's diligence and circumſpection, to try, whether even ſuch weather-glaſſes ought to be ſo far allowed of, as to hinder men from looking after any other kind of ways of eſtimating cold.

FOR, though the ſealing of theſe weather-glaſſes protect the included liquor from the preſſure of the air, and keep it from evaporating, yet it will not follow from hence, that they muſt be exempt from all the other imperfections, which we formerly mentioned to be imputable to weather-glaſſes.

I KNOW not, whether you will allow me to add on this occaſion, that tincted ſpirit of wine (and the like may, for aught we know, be ſaid of any ſuch liquor) being a particular mixture, in caſe it be allowed poſſible, that the ſubtile ſteams of ſuch bodies (as we formerly noted

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to be frigorifick in reſpect to ſome liquors) may inſinuate themſelves through the pores of glaſs; as it is granted, that the effluviums of the loadſtone do readily permeate it: in this caſe, I ſay, though I willingly allow it not to be likely, yet it is not abſolutely impoſſible, that ſome ſteams, that wander through the air, may be more or leſs cold, or may more promote or hinder an agitation among the minute parts in reference to it, than in reference to other liquors: as we formerly noted, that a grain or two of opium will exceedingly allay the warmth and motion of the whole maſs of blood in a man's body, though ten times that quantity will not ſenſibly refrigerate the tenth part of ſo much water. And that this may appear the leſs extravagant, I ſhall here add ſome mention of an odd phænomenon, that, as it were, by ſome fate has occurred to me, ſince I began the diſcourſe I am now upon: for whilſt I was yeſterday writing it, I had occaſion to examine by ſuch a ſealed weather-glaſs (as I have been ſpeaking of) the temper of a certain ſtrange kind of mixture, that towards the cloſe of this treatiſe, I ſhall have occaſion to take ſpecial notice of: and though to the touch it appeared but lukewarm, yet having put into it the ball, and part of the ſtem of the ſealed weather-glaſs, I found the included liquor ſlowly enough impelled up ſo high, that at length, to my wonder, it roſe eight or nine inches in a ſtem, which was not much above a foot long. But that which I relate, as the ſurprizing circumſtance, is, that when I had taken out the thermoſcope, and removed it again into a deep glaſs full of cold water, whence I had juſt before taken it out, to put it into the anomalous mixture, I had a mind to examine; the tincture in the weather-glaſs did not (as it was wont, and as any one would have expected) begin to ſubſide again towards its former ſtation, but continued within about half an inch or leſs of the very top of the inſtrument, though neither my own buſy eyes, nor thoſe of a perſon very well verſed in making and uſing thermoſcopes, could perceive, that the expanded tincture was any where diſcontinued by any air or bubbles, which at firſt we ſuſpected might poſſibly (though it were very unlikely) have been generated by the tepor of the mixture. But that, which continued our wonder, if not increaſed it, was, that during four or five hours, that the inſtrument continued in the cold water, and during ſome hours alſo, that it was expoſed to the air, the tincture did not ſubſide above half an inch; and, which is yet more ſtrange, having left the glaſs all night in the window of a room, where there was no chimney, I found in the morning, that its deſcent was ſcarce ſenſibly greater, for it continued about eight inches higher than the mark it ſtood at, when I firſt put it into the lukewarm mixture; and how long it will retain this ſtrange expanſion, is more than I can tell. But by this, and what I may have occaſion hereafter to relate, concerning this mixture, it may appear ſomewhat the more reaſonable to ſuſpect, than even ſealed weather-glaſſes furniſhed with high rectified ſpirit of wine, may in ſome (though very rare) conjectures of circumſtances, and from ſome peculiar agents, either by their inſinuating themſelves through the pores of the glaſs, or on ſome other account, receive impreſſions, that, as far as can eaſily be diſcerned, are not purely the genuine and wonted operations of heat and cold.

THE chymiſt *Orthelius* tells us, that the liquor diſtilled from the ore of magneſia or biſmuth (which ſeems to be the ſame mineral that we, in Engliſh, call tin-glaſs) will ſwell in the glaſs it is kept in, not only manifeſtly, but very conſiderably at the full moon, and ſhrink at the new moon; and if all my endeavours to procure that ore had not proved fruitleſs, I ſhould be able, by my own experience, to diſprove or confirm ſo admirable a phænomenon: but being as yet unfurniſhed to make the trial myſelf, leſt it might appear a vanity, ſo much as to mention (without rejecting it) a thing ſo very unlikely; I ſhall add, that ſince I find the thing, for the main, which was delivered by the chymiſt, employed as an argument by a famous mathematician (the Jeſuit *Caſatus* *) whoſe expreſſions are ſuch, as if he himſelf had obſerved, that even in ſtopt glaſſes, the forementioned mineral ſpirit increaſed very ſenſibly in bulk about the time of the full moon; which wonder being admitted, may not only countenance what we were ſaying, but hint ſome other very ſtrange things in nature. This brings into my mind, (what I have elſewhere mentioned) that a tincture of amber I had made with high rectified ſpirit of wine, did, for many months, in a well-ſtopt glaſs, diſcover itſelf to be affected with certain changes, which were thought to proceed from ſome ſecret mutations of the air, that did ſenſibly ſo work, as I had not obſerved it to do upon other liquors, wherein the ſpirit of wine abounded. And, perhaps, upon long and diligent obſervation, one might find a diſparity betwixt weather-glaſſes kept in the ſame place, but furniſhed with differing liquors; a diſparity, I ſay, that could not be ſo well aſcribed to any thing, as to the peculiar nature of the reſpective liquors, which, though of divers kinds, may (to add towards the facilitation of trials) be made of a very conſpicuous colour, by the ſelf-ſame metal, copper, which not only gives the known colour in aqua fortis, but affords us a fair ſolution in aqua regis, and it makes a liquor of a deep and lovely blue in ſpirit of urine, or of ſal armoniac, and the like: nay, I have found, that in good chymical oil of turpentine (for expreſſed oils are too eaſily congealed) the bare filings of it will yield a ſufficient tincture. But becauſe it is yet but a bare ſuſpicion,

Theatr. Chymic. vol. 6.

* *Vitrum optimè clauſum ne quid exſpirare poſſet, in loco ubi quieſceret, ſtatui, nec ſine animi voluptate licebat in pleniluniis manifeſta incluſi liquoris incrementa obſervare, in noviluniis vero decrementa,* &c. They are the words of *Paulus Caſatus*, in his *Terra Machinis mota*, Pag. 143. But ſince the writing of theſe preliminary diſcourſes, the author of them having conſulted, by the means of ſome ingenious friends, the learned *Caſatus*, finds, that he never made or ſaw the experiment himſelf, but relates it upon the authority of a certain Dutchman, whoſe name he adds not, and who therefore may probably be the ſame *Orthelius*, that is mentioned by the author of theſe preliminary diſcourſes; who thinks it requiſite to give the reader this advertiſement, becauſe *Caſatus* himſelf did not, as he ſhould have done, intimate, that he delivered this but upon another's credit.

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ſuſpicion, that ſealed weather-glaſſes, made of differing liquors, but in other points alike, may be otherwiſe uniformly affected by the temperature of the external air; I ſhall now add an obſervation already made, to ſhew, that even the ſealed weather-glaſſes, furniſhed with ſpirit of wine, are not ſo perfectly ſecluded from all commerce with external bodies, and liableneſs to their operations, but that they may be wrought upon otherwiſe than we think. For I have more than once obſerved, that even in ſealed thermoſcopes (made purpoſely at home for me, and with great care, by the experteſt maker of them) after a good while, and when no ſuch matter was expected, there have emerged bubbles, which, whether they proceeded from ſome undiſcernible particles of air, harboured in the pores of the water, which, in proceſs of time, by their union, came to make conſpicuous bubbles, or from ſome diſpoſed particles of the ſpirit of wine itſelf, by ſucceſſive alterations, brought to a ſtate of elaſticity, I now examine not; but only affirm, that ſometimes I have had, of theſe bubbles, great enough to poſſeſs the ſpace of many inches, in the ſhank of a long ſealed weather-glaſs, and I have been troubled with them in more weather-glaſſes than one or two: which I therefore take notice of, not only becauſe it ſerves to prove what I was ſaying, but becauſe it is very fit an advertiſement ſhould be given of it to prevent miſtakes. For when theſe bubbles are ſmall, and are generated, or happen to ſtay at or about the place where the ſpherical and cylindrical parts of the glaſs meet, they may eaſily (as I have obſerved) lurk unheeded, and reaching from ſide to ſide, ſo divide the ſpirit of wine in the ball from that in the ſtem, that the latter ſhall not be able to riſe and fall according to the changes of the weather; the bubble, notwithſtanding its aërial nature, being more indiſpoſed to be moved up and down in the ſlender ſtem of a ſmall weather-glaſs, than the ſpirit of wine itſelf, as we have elſewhere ſhewn, that when air is not forced, a bubble of it will not, in ſeveral caſes, ſo readily paſs through a very narrow paſſage, as would that groſſer fluid, water.

BUT all theſe difficulties (not to call them extravagancies) which I have been mentioning about ſealed weather-glaſſes, I repreſent not to ſhew, that it is (at leaſt as yet) worth while to ſuſpect us ſo far, as to employ all the diligence and inventions, that were requiſite to prevent or ſilence, the ſuſpicions of a ſceptick, or that might be thought upon, in caſe the matter did require or deſerve ſuch extraordinary nicety, but only to give men a riſe to conſider, whether it would be amiſs to take in (when occaſion preſents itſelf) as many collateral experiments and obſervations, as conveniently we can, to be made uſe of, as well as our ſenſories and weather-glaſſes, in the dijudications of cold. And, perhaps, an attentive enquiry, purpoſely made, would diſcover to us ſeveral other bodies, natural or factitious, which we might make ſome uſe of in eſtimating the degrees of cold. For though (to give an inſtance) water be thought to be the liquor, that is moſt ſuſceptible of ſuch an intenſity of cold, as will deſtroy or ſuſpend its fluidity; yet, not here to repeat what we formerly delivered of the eaſy congealableneſs of oil of aniſeeds, we have (as we elſewhere note to another purpoſe) diſtilled a ſubſtance from benzoin, which becomes of a fluid, a conſiſtent body, and may be reduced to the ſtate of fluidity again by very much leſſer alterations of the ambient air, as to heat and cold, than would have produced ice or thawed it. I could alſo here take notice of what I have ſometimes obſerved in amber-greaſe, diſſolved in high rectified ſpirit of wine, or in other ſulphureous or reſinous concretions diſſolved in the ſame liquor: for now and then, though it ſeemed a meer liquor in warm weather, it would in cold weather let go part of what it ſwallowed up, and afterwards re-diſſolve it upon the return of warm weather; ſome of theſe concretions, as I have ſeen in excellent amber-greaſe, ſhooting into fine figured maſſes, others being more rudely congealed. And I might alſo add, what I have obſerved in chymical liquors, (not unſkilfully prepared out of urine, hartſhorn, &c.) which would ſometimes ſeem to be totally clear ſpirits, and at other times would ſuffer a greater or leſſer proportion of ſalt to cryſtallize at the bottom, according to the mutations of the weather, in point of cold and heat. Such kind of inſtances (I ſay) I could mention, but I ſhall rather chuſe to proſecute my examples in that obvioueſt of liquors, water; and add, that even that may afford us other teſtimonies of the increaſed or leſſened cold of the air, than that which it gives us in common weather-glaſſes. For in ſome parts of *France* the watermen obſerve, that the rivers will bear boats heavier loaded in winter, than in ſummer; and I have upon inquiry been credibly informed, that ſeamen have obſerved their ſhips to draw leſs water upon the coaſts of frozen regions (where yet the ſea is wont to be leſs brackiſh) than they do on our Britiſh ſeas: which argues, that water is thicker and heavier in winter than in ſummer. Nay, I ſhall add, that not only in differing ſeaſons of the year, but even at ſeveral times of the ſame day, I have often obſerved the coldneſs of the air to be (regularly enough) ſo much greater at one time of the day than at another, that a glaſs bubble hermetically ſealed and poiſed ſo as to be exactly of the ſame weight with its equal bulk of water, as that liquor was conſtituted at one time of the day, would about noon, when the warmth, that the ſummer's ſun produced in the air, had ſomewhat rarified the water, and thereby made it, bulk for bulk, ſomewhat lighter than before, the bubble would ſink to the bottom of the water, which (for the better marking the experiment) I kept in a glaſs-tube; but when at night the coolneſs of the air had recondenſed the water, and thereby made it heavier, it began, by little and little, to buoy up the bubble, which uſually by morning regained the top of the water; and at other times of the day it not unfrequently happened, that the bubble continued ſwimming up and down betwixt the top and the bottom, without reaching either of them, ſometimes ſtaying ſo long in the ſame

L'Hydrographie du P. Fournier, Liv. 18. cap. 12.

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part of the tube, that it much ſurprized divers of the virtuoſi themſelves, who thought the poiſing of a weight ſo nicely, not only a very great difficulty (as indeed it is) but an inſuperable one. But of this experiment I elſewhere ſay more; and becauſe about other weather-glaſſes, I have ſaid ſo much already, I think it may not be improper to ſum up my thoughts concerning the criteria of cold, by repreſenting the following particulars:

1. THAT by reaſon of the various and unheeded pre-diſpoſitions of our bodies, the ſingle and immediate informations of our ſenſes are not always to be truſted.

2. THAT though common weather-glaſſes are uſeful inſtruments, and the informations they give us are in moſt caſes preferable to thoſe of our ſenſe of touching, in regard of their not being ſo ſubject to unheeded mutations; yet even theſe inſtruments being ſubject to be wrought upon by the different weights of the atmoſphere, as well as by heat and cold, may (upon that and perhaps ſome other accounts) eaſily miſinform us in ſeveral caſes, unleſs in ſuch caſes we obſerved by other inſtruments the preſent weight of the atmoſphere.

3. THAT the ſealed weather-glaſſes, we have been mentioning, are ſo far preferable to the common ones, as (eſpecially they not being obnoxious to the various preſſure of the external air) that there ſeems no need in moſt caſes to decline their reports, or poſtpoſe them to thoſe of any other inſtruments: but yet in ſome nice caſes it may be prudent (where it may conveniently be done) to make uſe alſo of other ways of examining the coldneſs of bodies, that the concurrence or variance to be met with in ſuch ways of examination, may either confirm the teſtimony of the weather-glaſs, or excite or aſſiſt us to a further and ſeverer inquiry.

4. THAT I would not have men too eaſily deterred from deviſing and trying various experiments (if otherwiſe not unlikely or irrational) about the eſtimating of cold, by their appearing diſagreeable to the vulgar notions about that quality. For I doubt, our theory of cold is not only very imperfect, but in great part ill grounded. And I ſhould never have ventured at trying to make ſealed weather-glaſſes, if I could have been withheld either by the grand Peripatetick opinion, that (to ſhun a void) water muſt remain ſuſpended in glaſſes, where, if it fall, the air cannot ſucceed it; or the general opinion even of philoſophers as well new as old, that air muſt be far eaſier, than any viſible liquor condenſed by cold.

DISCOURSE III.

Containing the ſecond Paradox, viz. Touching the Cauſe of the Condenſation of Air, and Aſcent of Water by Cold in common Weather-glaſſes.

THOUGH I thought here to end the preliminary diſcourſe, as doubting it may be thought prolix enough already, yet for confirmation of what I was lately noting, about the incompleteneſs of the theory of cold, (and becauſe the evincement thereof may give riſe to many trials, that may inrich the hiſtory of cold) I will here ſubjoin a diſcourſe formerly written on another occaſion. For though upon that account I am fain to leave out the beginning of it, as not ſuited to the preſent occaſion, yet the main body of the diſcourſe may be (I think not improperly) annexed to what has been already ſaid about weather-glaſſes; ſince it examines the cauſes of the principal phænomenon of them, and will perhaps help to diſcover the incompleteneſs of men's notions about cold, by ſhewing, that the true cauſe, even of the moſt obvious phænomenon of common weather-glaſſes (though almoſt every man thinks he underſtands it) has not yet been ſufficiently inquired into.

THE diſcourſe then, that firſt part of it (as foreign to our preſent purpoſe) being omitted, is as follows.

—— To proſecute our diſquiſition ſatisfactorily, it will concern us to conſider, upon what account the water riſes in cold weather, and falls in hot, in common weather-glaſſes, whoſe conſtruction being ſo well known, that we need not to ſpend time to ſet it down, we may forthwith proceed to take notice, that concerning the reaſon, why in theſe weather-glaſſes the water, or other liquor in the ſhank or pipe, aſcends with cold, and deſcends with heat; there are three opinions, that will deſerve our conſideration.

THE firſt is the common opinion of the ſchools and Peripateticks, and indeed of the generality of learned men of differing ſects, who teach, that the cold of the external air, contracting the air included in the weather-glaſs, and thereby reducing it into a narrower room than formerly it poſſeſt, the water muſt neceſſarily aſcend to fill the place deſerted by the retired air, leſt that ſpace ſhould become a vacuum, which nature abhors.

BUT againſt this explication, we have ſeveral things to object.

FOR firſt, I am not ſatisfied, that any of the ſchoolmen or Peripateticks (at leaſt of thoſe I have met with) have ſolidly evinced, that nature cannot be brought to admit of a vacuum. NOR do I much expect to ſee that aſſertion well proved, by theſe, or by any other, that forbear to make uſe of the argument of the Carteſians drawn from the nature of a body, whoſe very

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very eſſence they place in its having extenſion: which I ſay, becauſe about this argument I neither have yet publiſhed, nor do now intend to deliver my thoughts.

NEXT, it ſeems a way of explicating, that little becomes a naturaliſt, to attribute to the ſenſeleſs and inanimate body of water an aim at the good of the univerſe, ſtrong enough to make it act, as if it were a free agent, contrary to the tendency of its own private nature, to prevent a vacuum, that, as is preſumed, would be hurtful to the univerſe.

BUT theſe arguments we have elſewhere urged, and therefore need not inſiſt longer on them here.

THIRDLY, If you take a bolt-head, with a large ball and long ſtem, and do, with that and quickſilver, make the Torricellian experiment, there will be an inſtrument prepared like a common weather-glaſs, ſave that the ſtem is longer, and that the liquor is mercury inſtead of water; and yet in this caſe we ſee not, that the mercury, which remains pendulous in the pipe at the height of about thirty inches, offers to aſcend into the cavity of the bolt-head, to fill up the ſpace, whence the air was expelled by the mercury, and which the quickſilver alſo by its ſubſiding deſerted. And the outward application of cold bodies to the forſaken part of the head will not, perhaps, occaſion the riſing of the quickſilver $\frac{1}{4}$ of an inch, if half ſo much, though the like degree of cold would make the water aſcend in a vulgar thermometer, though ſhorter, to the height of ſeveral inches. But this argument I alſo, on another occaſion, further diſplay and vindicate.

WHEREFORE I ſhall add one more, taken from the conſideration of theſe ſealed weather-glaſſes, that are deſcribed in this preſent Hiſtory of Cold. For, in theſe the air does not ſhrink, but rather ſeems to be expanded, when the weather grows colder. If it be ſaid, that water being contracted by the cold, the air follows it, to prevent a vacuum; I anſwer, that thoſe, that ſay this, ſhould explain why, whereas in common weather-glaſſes the water aſcends to follow the air, in theſe the air muſt deſcend to follow the water; and why, ſince to avoid a vacuum, the one in common weather-glaſſes, and the other in ſealed ones, reſiſts contraction, nature does not rather make the air in common thermometers retain the extenſion, they conceive due to its nature, than put her ſelf to the double labour of ſuffering the air to be preternaturally condenſed, and compelling the water to aſcend contrary to its nature. But theſe arguments I will not urge ſo much as this other, that in our preſent caſe the above propoſed anſwer will by no means ſolve the difficulty. For if the water be really condenſed into leſs, and the air expanded into more ſpace, than they reſpectively poſſeſt before; I ſee not, how a vacuum or a worſe inconvenience will be avoided. For I demand, ſince glaſs is granted to be impervious to air and water, (as indeed elſe nature would not need to make water aſcend contrary to its own tendency in a common weather-glaſs) what becomes of the body, that was harboured in the ſpace deſerted by the water upon its condenſation? which queſtion thoſe, that do not ſay any thing eſcaped away through the glaſs, or that any thing was annihilated, will not eaſily anſwer. But this is not all; for I further demand, when the air expands itſelf to follow the water, how by that expanſion of the air, a vacuum both *coacervatum* (as the old Epicureans ſpoke) and *interſperſum*, is avoided. For the aërial corpuſcles cannot advance into this ſpace deſerted by the water, without leaving either in whole or in part the ſpaces they filled before; ſo that by this remove an aërial corpuſcle only changes place, but does not adequately fill any more place than it did before. But if it be ſaid, that the ſame air, without any ſubſtantial acceſſion, may adequately fill more ſpace at one time than at another; if this, I ſay, be pretended, I ſhall not urge, that it appears not, why it were not more eaſy for nature in common weather-glaſſes, as well as in ſealed ones, to rarify the air, which they teach to be ſo very eaſily rarified and condenſed, than to make the heavy body of water to aſcend. For I may very well reply, that I ſcarce know any opinion in natural philoſophy, that to me ſeems more unintelligible, and more worthy to be confidently rejected, than this harſh hypotheſis of rarefaction. Of which I ſhould think it injurious to ſo judicious a philoſopher, as my Lord *Brouncker*, to endeavour here to manifeſt the abſurdity, though I had not in another place ſhewn it already.

Defence againſt Linus, *chap.* 3.

THE next opinion, we are to conſider touching the cauſe of the aſcenſion of water by cold in weather-glaſſes, is that of Mr. *Hobbes*, who, in the laſt chapter of his book *de Corpore*, ſect. 12. having premiſed a delineation of a common weather-glaſs, ſubjoins this explication:

IN the ſixth and ſeventh articles of the 27th chapter (where I conſider the cauſe of cold) I have ſhewn, that fluid bodies are made colder by the preſſure of the air, that is to ſay, by a conſtant wind, that preſſeth them. For the ſame cauſe it is, that the ſuperficies of the water is preſſed at F, and having no place, to which it may retire from this preſſure, beſides the cavity of the cylinder between H and E, it is therefore neceſſarily forced thither by the cold, and conſequently it aſcendeth more or leſs, according as the cold is more or leſs increaſed. And again, as the heat is more intenſe, or the cold more remiſs, the ſame water will be depreſſed more or leſs by its own gravity, that is to ſay, by the cauſe of gravity above explicated.

BUT however the author of this explication, to prepare us to receive it, tell us, that however the above-mentioned phænomena *be certainly known to be true by experience, the cauſe nevertheleſs has not been diſcovered*; yet I confeſs, I think this newly recited aſſertion might as well have been placed after his explication, as juſt before it.

FOR firſt, whereas, he remits us to the ſixth and ſeventh articles of the 27th chapter (for the reference is miſprinted) as containing the

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grounds of this explication, I muſt profeſs my ſelf far from being ſatisfied with the general theory of cold delivered in that chapter, as being partly precarious, partly inſufficient, and partly ſcarce intelligible, as I ſhall elſewhere have occaſion to ſhew. And as for what he particularly alledges in the ſixth and ſeventh articles of a conſtant wind, that preſſes fluid bodies, and makes them cold, beſides that that is prooffleſsly affirmed, we ſhall anon have occaſion to mention an experiment, where water was not only much refrigerated, but turned into ice, though it were ſealed up in glaſs veſſels, and thoſe ſuſpended too in other glaſſes; wherein ſome of them had air about them, and ſome others were totally immerſed in unfreezing liquors; ſo that the water, that was ſealed up, was ſufficiently protected from being *raked* by the wind, as Mr. *Hobbes*'s conceit of the cauſe of freezing requires.

SECONDLY, I ſee no neceſſity, that the cold ſhould preſs up the ſuperficies of the water into the ſhank of the weather-glaſs, eſpecially ſince it is manifeſt, that the water will riſe with cold in a weather-glaſs kept in a ſtill place, and free from any ſenſible wind. Beſides that it ſhould be proved, and not barely affirmed, that an inſenſible motion deſerves the name of wind, and that ſuch a one is the cauſe of the refrigeration of water; and it ſhould be alſo ſhewn, how this wind comes to be able to raiſe the water, and that to the height of many inches more in one part of the ſuperficies than in another. Beſides all this, I ſay, we find by experience, that water poured into a bolt-head, till it have filled the ball, and reached a good way into the ſtem, will, upon a powerful refrigeration, ſhort of freezing, (which is the caſe of water in weather-glaſſes, when the air grows colder) manifeſtly ſhrink into a narrower room, inſtead of being impelled up higher in the pipe. And if in an ordinary weather-glaſs, with a long ſhank, you apply a mixture of ice or ſnow, and ſalt to the bolt-head, the water will readily aſcend in the ſhank to the height of divers inches, which, how it will be explained by Mr. *Hobbes*'s hypotheſis, I do not well ſee.

THIRDLY, I wonder he ſhould tell us, that the reaſon, why the preſſed water aſcends into the ſhank of the weather-glaſs, is, becauſe it hath no other place, into which it may retire from the preſſure of the wind; ſince he, rejecting a vacuum, and affirming the world to be every where perfectly full, ſhould not, methinks, have ſo ſoon forgotten, that in the very paragraph or ſection immediately preceding this, himſelf had told us, that he *cannot imagine, how the ſame place can be always full, and nevertheleſs contain ſometimes a greater, ſometimes a leſs quantity of matter; that is to ſay, that it can be fuller than full.* So that I ſee not, why the water ſhould find more room to entertain it, in the cylindrical cavity of the weather-glaſs already adequately filled with air, than other where. And in the ſealed weather-glaſſes we have above been mentioning, and wherein the water deſcends with cold, it will be very hard for Mr. *Hobbes* to make out the phænomenon according to his doctrine. Beſides that his explication gives us no account of the condenſation of the air by cold in ſuch weather-glaſſes, as thoſe, wherein the water deſcends with cold and riſes with heat.

Sect. 11. *of the ſame* 30*th chapter.*

FOURTHLY and laſtly, whereas Mr. *Hobbes* takes notice of no other cauſe of the depreſſion of water in weather-glaſſes by heat, but its own gravity, he ſeems to have but ſlightly conſidered the matter. For though, in ſome caſes, the gravity of the water may ſuffice to depreſs it, yet, in other caſes, that gravity alone will by no means ſerve the turn, but we muſt have recourſe to the expanſive motion or ſpring of the air included in the cavity of the glaſs. For if you place a thermometer with a large ball, wherein the water aſcends but a little way into the ſhank, in a window expoſed to the warm ſun, you will often perceive the ſurface of the water in the pipe to be a good deal lower than that of the water on the outſide of the pipe; which ſhews, that this depreſſion proceeds not from the bare ſinking of the water, but from its being thruſt down by the preſſure of the incumbent air; ſince the water's own weight would make the internal water fall but to a level with the ſurface of the external water, and not ſo much beneath it. And for further proof, you may, by keeping ſuch a weather-glaſs long enough in the hot ſun, bring the air ſo far to expand itſelf, as to drive the water out of the ſhank, and break through the external water in divers conſpicuous bubbles, after whoſe eruption the remaining air being again refrigerated by the removal of the weather-glaſs into a cooler place, the loſs of that part of the air, that eſcaped away in bubbles, will make the water aſcend higher in the ſhank, than in the like degree of cold it would formerly have been impelled. And thus much may ſuffice to ſhew the unſatisfactorineſs of Mr. *Hobbes*'s conceit.

THE third and laſt opinion we ſhall mention, is that of ſome ingenious modern naturaliſts, who acknowledging, that the air has a weight, (which Mr. *Hobbes* alſo does in effect admit, though he make not ſo good uſe of it as they) do by that explicate the aſcenſion of water in weather-glaſſes; teaching, that the cold of the ambient air making the included air ſhrink into far leſs room than it poſſeſt before, the water in the ſubjacent veſſel is, by the weight of the incumbent air, which preſſes on it more forcibly in all the other parts of its ſurface, than it is preſſed upon in that included in the ſhank, impelled up into that part of the ſhank, which was newly deſerted by the ſelf-contracting air.

BUT though this account be preferable by far to thoſe, which we mentioned beforeit, and though it be not only ingenious, but, as far as it reaches, true; yet to me I confeſs it ſeems not ſufficient, and therefore I would ſupply what is defective, by taking in the preſſure, (and in ſome caſes the ſpring) of the external air, not only againſt the ſurface of water, (for that the newly mentioned explication likewiſe does) but alſo againſt the internal or included air. For the recited hypotheſis gives indeed a rational account, why the water is impelled into

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to the place deſerted by the air; but then ſuppoſes, that the air is made to contract it ſelf by cold alone, when it makes room for the water, that ſucceeds in its place; whereas I am apt to think, that both the effects may proceed, at leaſt in great part, from the ſame cauſe, and that the preſſure of the contiguous and neighbouring air does, according to my conjecture, eminently concur to reduce the cooled air, ſhut up in the weather-glaſs, into a narrower ſpace. This it does in common weather-glaſſes, becauſe the ambient air retains the whole preſſure it has, upon the account of its weight; whereas the internal air, by its refrigeration, even when but equal to that of the external air, loſes part of the preſſure it had upon the account of its weakened ſpring.

BUT this, as I newly intimated, is not the ſole account, upon which the air may in ſome ſorts of weather-glaſſes impel up the water, and contribute to the condenſation of the air incumbent on the water. For in ſome circumſtances (one or two of which we ſhall produce by and by) it may ſo happen, that the reſt of the air, that bears up the water to be raiſed, will not be ſo much refrigerated, as the included air, that is to be condenſed; and conſequently the other air will have a ſtronger ſpring, than this laſt mentioned air will retain, and therefore the former will have a greater preſſure, than the latter will be able to reſiſt.

WE ſhall not now examine, whether the ſpring of the air depend upon the ſpringy ſtructure of each aërial corpuſcle, as the ſpring of wooll does upon the texture of the particular hairs it conſiſts of, or upon the agitation of ſome interfluent ſubtile matter, that, in its paſſage through the aërial particles, whirries each of them about, or upon both theſe cauſes together, or upon ſome other differing from either of them: but this ſeems probable enough, that as, when air, being ſealed up in a glaſs, is afterwards well heated, though it acquire not any greater dimenſions, as to ſenſe, than it had before, yet it has its ſpring much increaſed by the heat; as may appear, if the ſealed tip be broken under water, by the eruption of bubbles, by the endeavour of the impriſoned air to expand itſelf; ſo upon the refrigeration of the air, ſo ſealed up, though the additional ſpring (if I may ſo ſpeak) which the heat gave it, will be loſt upon the receſs of that heat, or as ſoon as the effect of that heat is deſtroyed, yet there will remain, in the included air, a conſiderable ſpring, and ſufficient to make it as well fill (at leaſt as to ſenſe) the cavity of the ſealed glaſs, as it did when its ſpring was ſtronger. And proportionably we may conceive, that though cold, at leaſt ſuch as we meet with in this climate of ours, does make the ſpring of an included parcel of air weaker than it was before the refrigeration of that air, yet it may not make it ſo much weaker, but that the aërial corpuſcles may be kept ſo far extended, as not at all (or ſcarce ſenſibly) to quit the room they poſſeſſed before, in caſe there be not, contiguous to them, any other body, which, by its preſſure, endeavours to thruſt them inwards, and ſo make them deſert part of that ſpace. Which clauſe I therefore add, becauſe, that if the caſe propoſed do happen, it is obvious to conceive, that the weakened ſpring of the air cannot retain ſo much force to reſiſt an external preſſure, as it would have, if the cold had not debilitated it; and conſequently this cooled air muſt yield and ſuffer itſelf to be condenſed, if it come to be expoſed to a preſſure, to which it was but equal before its being weakened. And ſuch in common weather-glaſſes is the preſſure, that is conſtantly upon the ſurface of the water without the pipe, upon the account of the gravity of as much of the air or atmoſphere as comes to bear upon it.

HAVING thus explained our conjecture, we will now proceed to the experiments we made to countenance it, as we find them entered in our looſe notes.

IN one of which, I find what follows:

WE took a phial capable of containing five or ſix ounces of water, and having filled it almoſt half full with that liquor, we inverted into it a glaſs-pipe of about ten inches long, and much bigger than a large ſwan's quill, ſealed at one end, and at the other filled top-full with water; ſo that the open orifice being immerſed under the veſſel'd water (of the phial) there remained no air at the top of the pipe. Then, as much of the orifice of the phial's neck, as was not filled by the pipe, being carefully cloſed with cement, that no air could get in or out, the phial was placed in ſnow and ſalt, till the veſſel'd water began to freeze at the top and bottom; and, according to our expectation, we found, that, notwithſtanding this great degree of infrigeration of the air in the phial, the water in the pipe did not at all deſcend: ſo that either the air did not ſhrink by ſo great a cold, or the water, whether to avoid a vacuum, or otherwiſe, did not remove out of the pipe to poſſeſs the place deſerted by the refrigerated air.

AFTERWARDS we endeavoured to repeat the experiment with the ſame glaſſes; but having had occaſion to be abſent a little too long (though not very long) we found, at our return, the upper and ſealed part of the pipe beaten out, which we ſuppoſed to have been done by the intumeſcence of the water in the phial upon its glaciation.

WHEREFORE we faſtned into the ſame phial another pipe, ſome inches longer than the former, and drawn very ſlender at the ſealed end, that it might eaſily be broken there; and having ſet the phial to freeze, as before, without finding the water to deſcend in the pipe, we did, with a forceps, break off the ſealed end, that the outward air might come to preſs upon the ſuſpended water, and, by it, upon the cooled air in the phial; whereupon, as we expected, the water was ſwiftly depreſſed, by our eſtimate, eight or ten inches, but not ſo low by a pretty deal, as the ſurface of the water in the phial.

AFTER this, by rarifying the air in the vial, and by blowing into it through the pipe, the water was raiſed within about half an inch of

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the top of the pipe, whoſe ſlender end being ſealed, the phial was again placed in ſnow and ſalt; but the ſpring of the air at the top, which was rarified before, was, by refrigeration, ſo weakened, that it was unable ſenſibly to depreſs the water; wherefore, breaking off the apex, as before, the upper air immediately drove it down divers inches.

OUR laſt trial therefore was, to leave in the ſame pipe about $3\frac{1}{2}$ inches of air rarified as little as we could, and placing the phial in ſalt and ſnow, as before, we obſerved, that the air in the pipe did, upon the refrigeration of the air in the phial, expand itſelf very little, though the water in the phial were in part turned into ice; but upon breaking off the ſlender ſealed end, the outward air preſently depreſſed the water above two inches beneath the laſt level, and by removing the glaſs into a warmer room, we found, that the water aſcended a pretty deal above an inch higher than the ſame uppermoſt level, whereby we probably concluded our weather-glaſs to be ſtanch.

THUS much I find together in one place, among my promiſcuous collections: but after this, coming to have the conveniency of glaſſes ſo ſhaped as to be eaſily ſealed, I judged it fit to make uſe of ſome of them, to keep even the moſt ſuſpicious from objecting, that I ſhould alſo have made ſome trials with glaſſes, which being hermetically ſeal'd, would be ſure moſt accurately to hinder all immediate intercourſe betwixt the internal and external air. And I remember, that once we took a glaſs, like the bolt-head of a common weather-glaſs, ſave that the ſmall end was drawn very ſlender, for the more eaſy breaking of the apex: and into this glaſs a convenient quantity of water was poured, and then the glaſs being ſealed up at the ſharp end and inverted, the water fell down to that end, and poſſeſt its due ſpace in the pipe. Then the round end of the glaſs having a mixture of ſnow and ſalt applied about it, though the internal muſt needs have been thereby much refrigerated, (as will be readily granted, and may be gathered from divers of the experiments mentioned in theſe papers) yet we obſerved not the water manifeſtly to riſe. And though an attentive eye ſhould in ſuch a trial diſcern ſome ſenſible intumeſcence in the water; yet that may well enough proceed from ſome little expanſion of the aërial particles, which we have elſewhere ſhewn to be uſually latitant in common water, upon the diminution of the preſſure of the air above the water, cauſed by weakening that air's ſpring by the cold. But when we had, to compleat the experiment, broken the ſlender end of the glaſs under water, the included air, becoming then contiguous to that had obtained immediate intercourſe with that water, whoſe ſurface was every where preſt by a pillar of the external air that leaned upon it, the water was by the gravity of that outward air haſtily impell'd into the cavity of the pipe (the ſpring of whoſe air was, as we ſaid, weakened by the cold) to the height, if I miſremember not, of ſeveral inches.

ANOTHER ſort of trial I remember we made after the following manner: We took glaſs-bubbles (blown with a lamp) ſome of about the bigneſs of a nutmeg, and ſome much greater; each of theſe bubbles we furniſhed with a very ſlender ſtem (often no bigger than a raven's quill) which was uſually divers, and ſometimes many inches long. Into this ſtem a drop or two of water being conveyed, might eaſily enough, by reaſon of the lightneſs of ſo little liquor, together with the ſlenderneſs of the cavity (which permitted not the included are to penetrate the water at the ſides, but rather impel up the intire body of it) be kept ſuſpended, and ſo betray very ſmall changes, (and much ſmaller than to be taken notice of by common weather-glaſſes) as to rarifaction and condenſation in the air it leaned upon. Now when in one of theſe inſtruments, if watching when the pendulous water was ſomewhat near the top of the ſtem, we nimbly applied to the orifice of that ſtem the flame of a candle, we could by that heat almoſt in a moment ſeal it up, by reaſon of the thinneſs of the glaſs, and the ſlenderneſs of the ſtem. And if then we placed the thus ſealed glaſs in a mixture of ſnow and ſalt, how much ſoever the air within the cavity of the ball muſt be, in all probability, refrigerated by this operation, yet it would ſcarce ſenſibly, and not at all conſiderably ſhrink; as we gathered from the pendulous waters remaining in the ſame place, or its falling at moſt but inconſiderably lower. But if then, with a pair of ſciſſars or otherwiſe, we dexterouſly broke off the ſealed end of the ſtem, and thereby expoſed the internal refrigerated, to the preſſure of the external air, the water immediately would be haſtily thruſt down, ſometimes divers inches below its former ſtation, and ſometimes quite into the cavity of the round end of the glaſs. To which we ſhall add, that not only, when theſe thermometers were ſealed, neither the uſual degrees of cold, nor thoſe of the heat in the ambient air would at all conſiderably depreſs or raiſe the pendulous water, which, if the glaſs were not ſealed, would, as we formerly noted, ſhew it ſelf wonderfully ſenſible of the mutations of the air, as to thoſe two qualities: But we ſometime purpoſely tried, that though upon the refrigeration of the formerly rarified air in the glaſs, the pendulous water were deſcending faſt enough, yet if even then we nimbly ſealed up the open orifice of the ſtem (which may eaſily be done in a trice) the deſcent of the water would be preſently ſtopt, and it would ſtay either juſt in, or very near the ſame part of the ſhank, wherein it chanced to be, when by ſealing of the glaſs it came to be fenced from the preſſure of the atmoſphere; and in that place it would continue till the ſealed end were broken off. For then in caſe the ambient air were as cool, as it was when the glaſs was ſealed, the water would for the reaſon already given be further depreſt, according as the weakened ſpring of the inward rarified air was more or leſs remote from an equality to the preſſure of the ambient air.

See more concerning theſe weather glaſſes in the firſt of theſe three diſcourſes.

BESIDES, for further trial, we took a large glaſs-egg with a long ſtem, which ſtem was purpoſely ſo bent, that it repreſented a glaſs-ſiphon,

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ſiphon, in whoſe ſhorter leg the glaſs was drawn very ſmall, that it might be the more eaſily firſt ſealed, and then broken.

THIS done, we got in a convenient quantity of water, which aſcended to a pretty height in both the legs of the bent glaſs, after which the ſhorter leg being nimbly ſealed after the manner hereafter to be mentioned, there remained a pretty quantity of air above the water in that ſhorter leg, which was purpoſely left there, that it might, by its ſpring, impel up the water in the longer leg upon the refrigeration of the air included in that longer leg. All this being done, the whole glaſs was ſo placed in a convenient frame, that the oval part of it was ſupported by the frame, beneath which the bended ſhank of the weather-glaſs did hang ſo, that a mixture of ice and ſalt might be conveniently laid upon this frame to ſurround and refrigerate the air included in the egg, without much cooling the air in the cylindrical part of the glaſs. The account, that I find of this trial in one of my notes, is this.

See the figure among the reſt of the ſchemes.

IN the greater bent egg, that was ſealed up with water, in both legs, upon the application of ice and ſalt to the ellipſis at a convenient time, the water in the longer leg aſcended a little, but not by our gueſs above a barley-corn's length, if near ſo much, and about four inches of air (as I remember) that were left in the ſhorter leg, expanded itſelf (to ſenſe) as much; but as ſoon as I broke off the ſlender wire, wherein the ſhorter leg ended, the external air ruſhing in made the water riſe about two inches and a quarter in the longer leg, and then, there not being water enough, broke through it in many bubbles.

THUS far the note, to which I ſhall only add, that in this caſe the aſcenſion of the water in the longer leg cannot be attributed to the weight of the air in the ſhorter leg, that being, I know not how much, too ſmall to lift up ſo much water, but to the ſpring of that air: and alſo that we need not marvel, the expanſion of that air ſhould be ſo ſmall, ſince ſome of the experiments, hereafter to be related, will ſhew us, that the refrigeration of the air in ſuch trials (as that newly recited) does not weaken the ſpring of it any thing near ſo conſiderably as one would expect. So that the air in the longer leg could yield but a very little to that in the ſhorter leg, eſpecially ſince the ſmallneſs of this laſt named proportion of air made its ſpring to be more eaſily and conſiderably weakened by a ſmall expanſion.

THUS far our paradoxical diſcourſe, which contains divers particulars, that, being added to the conſiderations, whereunto we have (by way of appendix) ſubjoined it, might afford us ſeveral reflections: but having dwelt too long on one ſubject already, we ſhall now conclude with this, upon the whole matter;

THAT there is ſomewhat or other in the buſineſs of weather-glaſſes, which (I fear) we do not yet ſufficiently underſtand, and which yet, I hope, that by other trials and more heedful obſervations we ſhall diſcover.

The Paper, that was prefixed (by way of a ſhort prefatory Addreſs) to the enſuing Hiſtory of Cold, when being to be brought in, and preſented to the Royal Society, *it was put into the hands of its moſt worthy Preſident, the Lord Viſcount* Brounker, *was as followeth.*

Little Chelſea, Feb. 14. 1662. S. A.

My Lord,

THE time your lordſhip and the ſociety appointed me for the bringing in of my papers, concerning cold, is ſo very ſhort, that to give you the fruits of my obedience as early as you are pleaſed to require them, I muſt preſent them you very immature, and I ſhould ſay very unfit for your peruſal, if you were not as well qualified to ſupply deficiencies and imperfections as to diſcern them. For of all the old obſervations, I made divers years ago, in order to the hiſtory of cold, I have not yet found enough to fill up one ſheet of paper: and as for thoſe, I made the laſt froſty ſeaſon, beſides that I was ſeveral times diverted by avocations diſtracting enough, the ſharpneſs of the weather, which gave me the opportunity of making ſome experiments, brought me an indiſpoſition, which by forbidding me to be often, and ſtay long in the cold air, hindered me from making divers others; and (which is worſt of all) whilſt I was confined to a place, where I wanted divers glaſſes, and other inſtruments I would have employed, the ways both by land and water were ſo obſtructed by the ſnow and ice, that I could not ſeaſonably procure them from *London*, and was thereby reduced to leave ſeveral trials, I ſhould have made, either unattempted, or unproſecuted. But leſt you ſhould think, that what I intend only to excuſe my unaccurateneſs, is meant to excuſe my pains, I ſhall without further apology apply my ſelf to do what the ſhortneſs of the time will allow me, which is little more, than to tranſcribe into this hiſtorical collection moſt of the particulars, which your lordſhip's commands exact, though haſte will make me do it in the very words, for the moſt part, that I find them, in a kind of note-book, wherein I had thrown them for my own private uſe; which I the leſs ſcruple now to do, not only becauſe the haſte, that exacts from me this way of writing, may ſerve to excuſe it in me, but that it may the better appear, how little I had deſigned to wreſt or byaſs them to any pre-conceived hypotheſis.

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The EXPERIMENTAL HISTORY *of* COLD *begun.*

TITLE I.

Experiments touching bodies capable of freezing others.

TO go methodically to work, we ſhould, perhaps, begin with conſidering, what ſubjects are capable, or not capable of harbouring the quality we are to treat of; and to invite us to this, it ſeems probable enough, that among the bodies, we are converſant with here below, there is ſcarce any except fire, that is not, at ſome time or other, ſuſceptible of actual cold, (at leaſt as to ſenſe) And even concerning fire it ſelf, till that difficulty be clearly determined, which we have elſewhere ſtarted; namely, whether fire be not, as wind, (at leaſt like ſuch as is made by air blown out of a pair of bellows) rather a ſtate of matter, or matter conſidered whilſt it is in ſuch a kind of motion, than a diſtinct and particular ſpecies of natural bodies, there may remain ſome doubt; ſince we ſee, that bodies, which may be either in a moment, as gunpowder, or (as far as ſenſe can judge,) totally, as high rectified ſpirit of wine, turned into fire, may yet immediately before their accenſion, be actually cold: and as to gunpowder, preſently after accenſion, its ſcattered parts caught in cloſed veſſels will alſo appear cold to the touch. But ſuch things nevertheleſs we muſt not now inſiſt on, partly becauſe it requires the reſolving of a ſomewhat difficult queſtion, which more properly belongs to the conſiderations about heat, where we have already handled it; partly becauſe our deſign in the following collections was not ſo much to gather and ſet down obſervations, that were obvious to any, that was furniſhed with a mediocrity of attention, as experiments purpoſely made in order to the hiſtory of cold; and partly too, becauſe in this collection, though we do, as occaſion ſerves, take notice of experiments and phænomena, that relate to cold in general, or indefinitely; yet our chief work has been to find out, and deliver, the phænomena of congelation, or of that intenſe degree of cold, which either does freeze the bodies it works upon, or at leaſt were capable of turning common water, fitly expoſed to it, into ice. And this may ſerve for a general advertiſement about the enſuing papers; and conſequently having premiſed it, we ſhall without any further preamble proceed to the ſetting down ſuch things, as we have tried and obſerved concerning thoſe matters; beginning with thoſe, that belong to the title prefixed to the firſt part, or ſection, of our hiſtory.

1. THE bodies, that are cold enough to freeze others, are in this climate of ours but very few, and among the moſt remarkable is a mixture of ſnow and ſalt, which, though little known, and leſs uſed here in *England*, is in *Italy* and ſome other regions much employed, eſpecially to cool drinks and fruits, which men may eaſily do, by burying, in this mixture, glaſſes, or other convenient veſſels, filled either ſolely with wine, or other drinks, or elſe with water, that hath immerſed in it the fruits to be refrigerated.

2. THE circumſtances we are wont to obſerve in making and employing this mixture, we ſhall hereafter in due place deliver; and therefore here we ſhall only take notice, that we could not find upon ſome trials, that ſuch glaſſes filled with water, as would be frozen eaſily enough by this mixture of ſnow and ſalt, would be in like manner frozen, in caſe we employed ſnow alone, without mingling any ſalt with it I deny not, that it is very poſſible, that in very cold countries, as well ſnow as beaten ice may freeze water poured into the intervals of its parts. But there is great odds betwixt water ſo intermingled with ice or ſnow, and only ſurrounded with it in a veſſel, where the water is, as it were, in one entire body, and of a comparatively conſiderable thickneſs: and there is alſo a great difference betwixt the degrees of coldneſs in the air of frigid regions, and of *England*. And perhaps too there may be ſome diſparity betwixt the degrees of coldneſs of ice and ſnow in thoſe climates, and in ours. And we muſt have a care, that in caſe a phial full of water buried all night ſhould freeze, we aſcribe not the effect to the bare operation of the ſnow, which may be (entirely, or in great part) due to the coldneſs of the air, which would, perhaps, have performed the effect without the ſnow.

3. BUT though ſnow and ſalt mixt together will freeze water better than ſnow alone, yet we muſt not think, that there is any ſuch peculiar virtue in ſea-ſalt, to enable ſnow to freeze, but that there are divers other ſalts, each of which concurring with ſnow is capable of producing the like effect. For we found upon trial, that we could freeze water without the help of ſea-ſalt, by ſubſtituting in its place, either nitre, or alum, or vitriol, or ſal armoniac, or even ſugar; for either of thoſe being mingled with a due proportion of ſnow, would ſerve the turn, though they did not ſeem equally to advance the congealing power of the ſnow; nor ſcarce any of them did do it ſo well as ſea-ſalt. But of this elſewhere more.

4. WHEN we had made the newly-mentioned trials, ſome particular conjectures, we have long had about the nature of ſalts, invited us to try, whether, notwithſtanding the comminution and conſequent change produced in ſalts by diſtillation, the ſaline corpuſcles, that abound in the diſtilled liquors of thoſe concretes, as well as in their ſolutions, would not likewiſe, by being mixt with it, enable ſnow to freeze water, at leaſt in ſmall and ſlender glaſſes? This we firſt went about to try with good ſpirit of ſalt: but we found, as we feared, that though it made a ſufficiently quick diſſolution of the ſnow it wrought upon, yet its fluidity hindered it

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it from being retained long enough by the ſnow, to the bottom of which it would fall, before they had ſtayed ſo long together, as was requiſite to freeze ſo much as a little eſſence-bottle full of common water.

5. WHEREFORE we bethought our ſelves of an expedient, whereby to try the operation, not only of thoſe ſpirits, but of divers other bodies, which were unapt for a due commixture of ſnow after the way newly mentioned, or of which we had too little, or valued them too much, to be willing to ſpend quantities of them upon theſe trials. And this way (that remains to be mentioned) we ſomewhat better liked, becauſe the experiments made according to it would alſo prove experiments of the tranſmiſſion of cold through the extremely cloſe body of glaſs.

AND even in this way of trying, we did at firſt meet with a diſcouragement, which, leſt it ſhould happen to others, we ſhall here take notice of; namely, that having put a convenient quantity of ſnow into a ſomewhat thick green glaſs phial, though we copiouſly enough mixt with it a ſomewhat weak ſpirit of ſalt, (being loth to employ the beſt we had) and having well ſtopt the veſſel, did carefully ſhake together, and thereby agitate the mixture in it, yet the glaſs appeared only bedewed upon the outſide, without having there any thing frozen. But ſuſpecting, that the thickneſs of the glaſs might be that, which hindered the operation of the included mixture, we put ſnow and a convenient proportion of the ſelf-ſame ſpirit of ſalt into a couple of thin phials, one of which we cloſed exactly, and the other negligently, and having long ſhaken them, we found, that what adhered to them on the outſide, was (though but ſomewhat faintly and thinly) frozen.

6. AND, as to this ſort of experiments, we ſhall here obſerve once for all, that the ſnow or ice included, together with the ſaline ingredient (whatever that were) was always thawed within the glaſs; and that conſequently, it was the condenſed vapour of the air, or other liquor that adhered to the outſide of the glaſs, which was turned into ice, which is the reaſon, why in mentioning theſe experiments we often uſe the word freeze in a tranſitive ſenſe, to ſignify the operation of the frigorifick mixture upon other bodies.

7. THIS premiſed, let us proceed to relate, that we afterwards took oil of vitriol, and mixing it with ſnow in ſuch another phial as that laſt mentioned, we found its freezing power far greater than that of ſpirit of ſalt. And leſt it ſhould be pretended, that in theſe experiments the cold was not tranſmitted through the ſides of the glaſs, but that the air within the phial, highly refrigerated by the mixture, did upon the account of their free intercourſe enable the air contiguous to the outſide of the phial to freeze the dew it met with ſticking on it; we proſecuted the experiments with the addition of this circumſtance, that on ſeveral occaſions we ſealed up the phial, that contained the ſnow and the other frigorifick body it was mixed with, and afterwards by the help of this mixture froze the externally adhering moiſture.

8. HAVING then, according to this way, ſubſtituted ſpirit of nitre for oil of vitriol, or ſpirit of ſalt, we found, that it froze yet more powerfully than either of thoſe two liquors, and continued to do ſo in thoſe parts of the outſides of the glaſs, that were adjacent to the included ſnow, till that ſnow was almoſt totally reſolved into a liquor. This we tried both in a thin ſealed glaſs, and in a pretty thick glaſs ſtopped only with a cork.

9. AFTERWARDS we ſucceſsfully enough tried the experiment with ſpirits leſs acid, as not only with ſpirit of vinegar, but with ſpirit of ſugar; I mean the red empyreumatical ſpirit forced over in a retort, which mixed with ſnow, according to the manner of the experiment, did at length freeze the externally adhering moiſture. But the films of ice were very thin, and very apt quickly to diſappear.

10. HAVING thus made a number of trials with acid ſpirits, we thought fit to make ſome with urinous ſpirits, that abound in volatile ſalt; and accordingly having mixt ſpirit of urine and ſnow in an open phial, and agitated them, we found, that the external moiſture did diſcernably, though not very ſtrongly, freeze.

BUT with ſpirit of ſal armoniac drawn from quick-lime (according to the way I have delivered in another treatiſe) the operation was quick and powerful enough.

11. HAVING tried to freeze water with acid, and with volatile ſpirits apart, we thought it not amiſs to try what they would do both together; and accordingly pouring upon ſnow both ſome ſpirit of urine, and a little oil of vitriol, and ſhaking them into the ſnow in an open phial, we found, that the mixture did freeze, though the glaciation, in this caſe produced, were very languid.

12. HAVING thus tried ſalts diſengaged from their groſſer parts, or ſhattered into corpuſcles by diſtillation, we made ſome trial likewiſe with groſſer ſalts, as with ſal-gem, with a ſublimate made with common ſublimate and ſal armoniac, nay, and with both loaf and kitchen ſugar, with all which, among the like bodies, that I can now remember, the experiment ſucceeded well enough: alſo a very ſtrong ſolution of pot-aſhes, mixed with ſnow in an open ſingle phial, did freeze, but that very faintly. And both a very ſtrong ſolution of very pure ſalt of tartar, and (at another time) a ſtrong ſolution of pot-aſhes, being the one as well as the other, mixed and agitated with ſnow in a ſingle phial, produced films of ice (though thin ones) on the outſide of the glaſs.

13. AFTER this, we thought fit to make a trial of another kind, of which I find this account among my notes. We filled a ſingle phial with ſnow, and then poured into it a convenient proportion of a ſtrongly ſweet ſolution of minium in ſpirit of vinegar, and having ſhaked the mixture together, we found, that this ſweet ſugar of lead did, as well as acid and alcalizate ſalts, excite the cold of the ſnow ſo much, as to produce films of ice on the outſide of the glaſs: but a parcel of the ſame ſolution, being

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for divers hours kept in ſnow and ſalt, was not thereby frozen.

IN order to the diſcovery of ſome hints of the account, upon which the above-mentioned mixtures were more intenſely frigefactive than ſnow alone, we ſealed up a ſingle phial full of ſnow unmingled with any other ingredient, and found it to thaw much more ſlowly, than any of thoſe parcels of ſnow, which we had mixt with ſalts or ſpirits.

IN proſecution of this conjecture, we ſhall add, that, for aught we could find, by divers trials, no ſalt, that helps not the ſnow to diſſolve faſter than elſe it would, did enable it to produce ice, though uſually it did produce dew on the outſide of the phial, that contained the mixture; and accordingly, neither cryſtals of tartar, nor borax, both beaten to powder, nor, which is more, (conſidering what we lately noted of the effects of another ſort of ſublimate) would ſublimate enable the ſnow to freeze; as well the powder of ſublimate as that of borax, and that of tartar, lying for a great while in the ſnow undiſſolved.

14. BELONGING to this matter, I find among my papers alſo this note.

[WATER of quick-lime (made by quenching ſtore of unſlacked lime in common water) twice tried, would not make ſnow freeze, perhaps becauſe though the water were kept ſtopt, yet the liquor having been kept in the glaſs a twelve-month, and more; probably the ſpirits may have flown away, which I find, by inquiring of one that drinks much lime-water, that it abounds with, when freſh, and grows deſtitute of a while after: and poſſibly alſo the badneſs of the lime was the cauſe, why being mingled with ſnow it would not freeze, though all the phials, that did not freeze, did yet gather ſtore of dew on the outſides (perhaps becauſe of the ſnow, whoſe melting alone may ſuffice) to produce that effect.]

15. IT may ſeem ſomewhat more ſtrange, that diſtilled oil of turpentine, which is ſo hot and fiery a liquor, ſhould not enable ſnow to freeze; but this agrees not ill with the conjecture lately mentioned, for it will hereafter appear, that in oil of turpentine ice diſſolves ſlower than in divers other liquors, without excepting common water itſelf.

16. AND yet notwithſtanding the bad ſucceſs of this trial, we were not diſcouraged from making another with ſpirit of wine; for though, according to the common opinion of chymiſts and phyſicians, it be a meer vegetable ſulphur, yet we, that have elſewhere ventured to aſcribe ſome ſuch operations to it as chymiſts would have belong to ſaline liquors, did not ſcruple to ſeal up, in a ſingle phial almoſt filled with ſnow, a convenient quantity of the pure ſpirit of wine, (drawn off from quick-lime, the better to dephlegm it) and of this mixture we found the operation more powerful than any of thoſe we have formerly mentioned: for the freezing virtue of this did not only laſt long, both in the ſealed ſingle phial, and in another that was open, but the incloſed mixture preſently cruſted the outſide of the glaſs (or of the neck, if it were made to fill that) with ice, which might be taken off in flakes of good breadth, or in pieces of good thickneſs. Nay, it preſently froze urine into figured ice, which might be taken off in ſcales.

17. THIS laſt circumſtance puts me in mind of another experiment, whereby we tried by a vigorous mixture of ſnow, and ſome choice ſpirit of nitre, we had met with, to freeze liquors of more difficult conglaciation than fair water.

WE took then ſome ſnow, and mingled with it ſome of the newly mentioned ſpirit of nitre in ſo lucky a proportion, that it froze very vigorouſly and very ſuddenly; inſomuch, that once almoſt as ſoon as it was ſet to the ground, it froze the phial to the floor it was ſet on, and the outſide of the glaſs, that contained this mixture, we wetted with ſpirit of vinegar, which was frozen into pretty thick ice, but yet (not quite to forget that circumſtance) retaining the ſalt taſte of ſpirit of vinegar. And though this mixture would not diſcernibly freeze ſpirit of nitre on the outſide, yet it tranſmitted cold enough to freeze weak ſpirit of ſalt, and to give us the pleaſure of ſeeing ſome ſaline liquors preſently turned into figured ice; as not only the laſt mentioned ſpirit exhibited ſome little (as it were) ſaline icicles croſſing each other, and quickly vaniſhing, but (which was far prettier) having often obſerved, that ſal armoniac being diſſolved in water, and the ſolution being put very ſlowly to evaporate part, but not too much, away, the remaining liquor would, in the cold, ſhoot into parcels of ſalt very prettily figured, ſome of them reſembling combs with teeth on both ſides, and others reſembling feathers: having obſerved this, I ſay, and being deſirous to try, whether the ſpirit of ſal armoniack, diſtilled by the help of quick-lime, being put to congeal on the outſide of a glaſs, would not afford a reſemblingly figured ice; we found upon trial, both that the mixture was able to freeze that ſubtile ſpirit, and alſo, that it ſhot into branches almoſt like thoſe, exhibited by ſuch ſalts undiſtilled. And it was not unpleaſant to behold, how upon inclining the glaſs ſo, that the freezing mixture reſted a little, near any part of the ſpirit, this liquor would ſhoot into ſuch branches as we have been ſpeaking of, ſo nimbly, that the eye could plainly diſcern them, as it were, to grow, and haſtily overſpread the ſurface of the glaſs, but thoſe branches were wont quickly to vaniſh.

I HAD almoſt forgot to mention, that I tried the freezing with ſnow, and divers fermented liquors undiſtilled, inſtead of ſpirit of wine; and though the experiments ſucceeded not with ſmall beer, much leſs with water, yet there was a glaciation, though but ſlight, produced not only by the addition of wine, but even by that of moderately ſtrong ale.

18. HAVING obſevred, that the liquors and other bodies, that aſſiſted the ſnow to freeze, were generally ſuch as haſtened its diſſolution, we thought it not altogether unworthy the trial, to examine, what would be the event of procuring a ſpeedy diſſolution of the ſnow, by ſubſtituting bodies actually warm, inſtead of

potential

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potential hot ones: of this ſort of trials, I find among my notes theſe two regiſtred.

[1. INTO a ſingle phial almoſt filled with ſnow, there was poured a pretty quantity of well-heated ſand, that it might diſſolve the ſnow in many places at once, without heating the ambient air, or the outſide of the glaſs: but though the ſolution of the ſnow ſeemed to ſucceed well enough upon the ſhaking of the veſſel, yet the outſide of the glaſs was only bedewed, not frozen.

2. INTO another ſingle phial almoſt filled with ſnow, we poured ſome water, which we judged of a convenient warmth, and we poured it in by a funnel, that had but a ſlender orifice beneath, that the warm water might fall into the middle of the ſnow, without running to the ſides; and taking a convenient time to ſhake the glaſs, we did by this way produce a very conſiderable degree of cold, and much dew on the outſide, but were not ſatisfied, that any of that dew was frozen, though the ſucceſs would have invited us to have made further trials in greater glaſſes, if we had had any more ſnow at hand.]

Wherefore this experiment is to be further and more artificially tried.

19. IT is a common tradition, not only among the vulgar, but (I preſume, upon their account) among learned men, that the oftentimes variouſly, and ſometimes prettily enough figured hoar froſt, which is wont to appear upon glaſs windows in mornings, preceded by froſty nights, are exſudations, as it were, that penetrating the glaſs-windows, are, upon their coming forth to the cold external air, frozen thereby into variouſly-figured ice. How groundleſs this conceit is, may be eaſily diſcovered, if men had not ſo lazy a curioſity, as not to try (which they may do in a moment, and without trouble) whether the ice be, according to the tradition, on the outſide of the window, and not contrary to it on the inſide, where indeed it is generated of the aqueous corpuſcles, that ſwimming up and down in the air within the room, are by the various motion, that belongs to the fluid bodies as ſuch, brought to paſs along the window, and thereby the vehement cold of the neighbouring external air, communicated through the glaſs, condenſed into dew, and frozen into ice.

20. AND becauſe divers modern naturaliſts have taught (I think erroneouſly) that glaſs is eaſily enough pervious, not only to air, but to divers ſubtile liquors, leſt the favourers of this doctrine ſhould object, that we have ill aſſigned the natural cauſe of the ice, appearing on the outſide of the glaſs in the former experiments, which, according to them, may rather proceed from the ſubtler (but yet viſible) parts of the exceſſively cold mixture of the ſnow and ſaline bodies penetrating the pores of the glaſs, and ſettling on the outſide of it: to obviate this objection, I ſay, and to confirm what we have taught in another treatiſe about the wandring of ſtore of aqueous vapours through the air, we will add the following experiments, purpoſely made to evince theſe truths.

21. AT one time four ounces and a quarter of a mixture of ice and ſalt, being incloſed in a phial, and thereby enabled to condenſe the vapours of the ambient air, was by their acceſſion increaſed 12 grains.

ANOTHER time a phial, wherein ſnow (weighing two ounces ſix drachms and an half) was ſuffered to condenſe the vapid air, the dew, that partly adhered to it, and partly fell from it, made the whole weigh four grains more than the phial did, when it was firſt put into the ſcale; in which ſcale we found ſome water flowing from the dew, which gave that increaſe of weight. And here let me add by the way, that the tip of this ſealed phial being broken under water, ſucked in a conſiderable quantity of it: whether, becauſe of ſome little rarefaction of the air included in the ſealing, or becauſe of the infrigidation of that air by the ſnow, or for both theſe reaſons, or any other, I ſhall not now diſpute.

22. BUT other experiments to the ſame purpoſe we made, wherein the increaſe of weight was more conſiderable; and that the way, we uſed, may be the better underſtood, and the concluſion built upon it the more undiſcuſſed, we will add a couple of trials, that we find among our notes concerning this matter.

[IN a ſingle phial we ſealed up as much ſnow and ſalt, as afterwards, when melted, we found to weigh between five and ſix ounces; after a while, the ſalt beginning to melt the ſnow, the dew on the outſide began to congeal, and being rubbed off, the hoar froſt would quickly begin to come again. This phial for further trial being put into a pair of ſcales with a counterpoiſe, after a while, as the vapours, that wandered through the air in the warm room, happened to be detained more and more upon the outſide of the glaſs, and to be there frozen, the ſcale, wherein the glaſs was, began to be depreſt, and to ſhrink lower and lower; after which, by adding a little to the counterpoiſe, we reduced them again to an æquilibrium; and yet after a while, the ſcale, that held the phial, ſubſided again more and more, till the included ſnow was melted: ſo that to reduce the ſcales to their firſt æquilibrium, we were fain to add in all to the counterpoiſe a weight, which we eſtimated to be about eight or ten grains, (for we had then no great weights by us.) The phial being taken out, there appeared near half a ſpoonful of liquor in the ſcale it ſtood in, which proceeded from the thaw of the ice, that was generated about it. But in that part of the ſcale, which was covered with the convex part of the bottom of the glaſs, there appeared no wet.

A like or ſmaller quantity of ſnow and ſpirit of wine being ſealed up in a ſingle phial, the outſide quickly appeared caſed with ice as high as the mixture reached within, and this phial alſo being counterpoiſed in a pair of ſcales, did by degrees depreſs the ſcale, that held it, till it had ſunk it very low, and about ſeven grains did but reduce the ſcales to an æquilibrium; but the ſcales being ſomewhat ruſty, we could not make the trials with that exactneſs we deſired.]

23. BUT at other times, when the experiment was more luckily, though not more carefully

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tried, with better ſcales, the increaſe of weight from the condenſed vapours of the air was ſomewhat more conſiderable; for I find in a ſhort note,

[THAT at one time a mixture of ſpirit of wine and ſnow, weighing three ounces and three quarters, afforded of condenſed vapours about 18 grains.

AND at another time a mixture of ſnow and ſal gemmæ, weighing three ounces and ſeventy grains, procured us an acceſſion of water weighing about 20 grains.]

TITLE II.

Experiments and obſervations touching bodies diſpoſed to be frozen.

1. IT were almoſt endleſs to try particularly, which bodies are or are not capable of congelation, and the degree of cold would alſo in ſuch experiments be (as near as men can) determined; becauſe many bodies will freeze in one degree of cold, that will not in another: wherefore we are willing to leave theſe trials to thoſe, that have more leiſure and opportunity to proſecute them, and ſhall only ſet down ſome, and thoſe ſomewhat various, that we may not leave this part of the Hiſtory of Cold quite unfurniſhed. And we muſt mention the fewer, becauſe, being in the country, we were not provided of divers of the bodies, which we ſhould have expoſed.

2. IN very cold ſnowy weather, we tried, that (beſides common water) urine, beer, ale, milk, vinegar, and French and Rheniſh wine (though theſe two laſt but ſlowly) were turned into ice, either totally, or in part. But ſuch inſtances will poſſibly be thought too obvious to be inſiſted on; therefore I ſhall add, that not only we froze a ſtrong ſolution of gum arabick, and another of white ſugar in common water, but that we took alum, vitriol, ſalt-petre, and ſea-ſalt, and made of each of them in a ſingle phial as ſtrong a ſolution as we could; we alſo made a ſtrong ſolution of verdegreaſe in fair water (which was thereby deeply coloured) all theſe we expoſed to the cold air. The ſolution of alum, nitre and verdegreaſe froze without affording any notable phænomena, either in the figuration of the ice, or otherwiſe: of the ſolution of vitriol there remained, at the bottom of the glaſs, a pretty quantity unfrozen, and of a clear ſubſtance, whoſe colour was very high of the vitriol; whereas the upper part of the ſame ſolution differed very little in colour from common ice.

3. BUT becauſe it ſeems not ſo ſtrange, that theſe groſs ſorts of ſaline bodies ſhould be turned into ice, we thought fit to try, whether or no alſo divers ſalts, freed from the groſſer parts of their concretes by the fire, were not likewiſe capable of congelation. We expoſed therefore ſpirit of vinegar in one ſmall glaſs, and ſpirit of urine in another, to an intenſe cold, and found, that not only the former, but the latter alſo froze.

4. WE took likewiſe ſome of the fiery lixiviate ſalt of pot-aſhes, and a ſingle phial, in which we put, to two ounces of water, a drachm of the alcali, and expoſing it to a very ſharp air, we did, when we came to ſee the ſucceſs of the trial, find ice lying on the topin little ſticks (ſomething croſſing one another) almoſt like the cryſtals of rocked petre; and beſides theſe, that lay levelled, there were others, that ſhot downwards in very great numbers.

5. WE alſo found, that oil of tartar per deliquium, or at leaſt a ſtrong ſolution of the fixt ſalt of tartar, though it ſeemed much to reſiſt the cold, yet it was once by ſnow and ſalt brought to congelation.

Appendix to the IId. *Title.*

SINCE I wrote the preſent book concerning cold (expecting ſome of the appendices) having once had the opportunity of an hour's diſcourſe with an ingenious man, that not only lived ſome years in *Muſcovy*, but was, and is ſtill phyſician to the great monarch of that empire; and having likewiſe at other times converſed with navigators, and ſome other credible perſons, that had travelled either to *Greenland*, *Terra Nova*, or other gelid climates, I propoſed them divers queſtions; by their anſwers to which, I learned ſome particulars, which, together with others, that I have met with in voyages and other books, I think it not amiſs to annex by way of appendices to the foregoing, and ſome of the following ſections, or titles.

ABOUT the freezing of common expreſſed oils, I know not well what to determine; for that they may, by a very intenſe cold, be deprived of their fluidity, and be made capable of being cut into portions, that will retain the figure given them, my own trials invite me to believe: but whether ſuch oils will be turned into true (by which I mean) hard and brittle ice, is a queſtion ſcarce to be determined by any experiments we can make here in *England*, where we could not reduce oil-olive into ice. And for the relations of thoſe, that have lived in colder countries, I find them to diſagree: for when I asked the lately mentioned doctor the queſtion, how far he had known oil congealed in *Muſcovy?* he anſwered me, that it did there freeze much harder than in our climate, but would not, that he had obſerved, be turned into true and perfect ice. On the other hand, I find the teſtimony of that ingenious navigator captain *T. James*, who relating the effects of cold he met with in the iſland, where he and his men were forced to winter, does in one place reckon oil among the liquors, ſuch as vinegar, and ſack, that even in their houſe was firmly frozen, and more expreſly elſewhere. "All our ſack *Page* 58. "(ſays he) vinegar, oil and every thing elſe, "that was liquid, was now frozen as hard as a "piece of wood, and we muſt cut it with a "hatchet." And *Olaus Magnus* ſpeaking of the fights, wont to be made upon the ice in the northern regions, *Glacialis congreſſus* (ſays he) *fit in laneis calcibus, non pellibus, aut coriis unctis: vis enim frigoris, quodcunque ſit unctuoſum, convertit in lubricitatem glacialem.* *Olai Magni Gent. Sept. Hiſt. l.* 11. *c.* 24.

THERE being a great ſimilitude in point of inflammability, and diſpoſition to mix with many ſubtile oleous bodies, betwixt ſpirit of wine

wine and oil, and as great an affinity in divers other regards, betwixt that ſpirit and both aqueous and ſaline liquors, with which it will readily mix; I had a great curioſity to know, what kind of change would be produced in vinous ſpirits, in caſe they were expoſed to a cold great enough to work a viſible change in their texture. I therefore ſolicitouſly inquired of the *Ruſſian* emperor's lately mentioned phyſician, whether or no he had obſerved in *Muſcovy* any manifeſt change produced by cold in hot waters, and ſpirit of wine? To which he returned me this anſwer; that common aniſeed-water, and the like weak ſpirits, would be turned into an imperfect kind of ice; and that even the very ſtrong ſpirits, though they would not be turned into ice, would be turned into a kind of ſubſtance like oil.

TITLE III.

Experiments touching bodies indiſpoſed to be frozen.

1. WE found many liquors, whoſe ſubtile parts being by diſtillation brought over, and united into very ſpirituous liquors, and ſo either totally, or in great meaſure freed from thoſe phlegmatick or aqueous parts, that diſpoſe bodies to congelation, could not be brought to freeze, either by the cold of the external air, to which in froſty nights we expoſed them, or by ſuch an application of ſnow and ſalt, as ſerved to freeze other bodies.

2. OF this ſort were, among acid menſtruums, aqua fortis, ſpirit of nitre, of ſalt; alſo oil of turpentine, and almoſt all, (I add the word almoſt, becauſe the eſſential oil of aniſeeds and the empyreumatical oil of common oil will loſe their fluidity in a leſs degree of cold, than that of our mildeſt froſts,) I ſay almoſt all the chymical oils we had by us, as likewiſe ſpirit of wine, and other ſtrong ſpirits of fermented liquors, and even ſack itſelf, if it were good, would very hardly be brought to afford us any ice at all: but among the many liquors, that would not freeze, there were a few, whoſe trials afforded us ſome circumſtances not altogether unworthy their being mentioned.

As 1. I being deſirous to ſatisfy ſome friends, that it was the briſk ſpirit of the grapes, whether reſulting from, or extricated and exalted by fermentation, that kept (all) the reſt of the ſack from freezing; I took a parcel of that liquor, that would afford us no ice at all, and by the help of a lighted candle, or ſome other actually flaming body, kindled it; and letting the inflammable part burn away, the remaining part of the liquor (which was by vaſt odds the greateſt part) was eaſily brought to freeze.

NEXT, when the formerly mentioned trial was made with water and pot-aſhes, we likewiſe, in another glaſs, expoſed a ſolution, wherein the proportion of ſalt of pot-aſhes, in reference to the water, was four times greater; there being in this ʒii. of the ſalt to ʒj. only of water: and this ſolution, though the glaſs were covered with hoar froſt and ice on the outſide, froze not at all within. And likewiſe, when another time we made a very ſtrong ſolution of ſalt of tartar, that was very pure and fiery, it did not freeze, though a conſiderably ſtrong ſolution of ſalt of pot-aſhes, that was expoſed with it, did. So that theſe experiments about the glaciation of lixiviate liquors muſt be repeated, to be reduced to a certainty.

3. THAT the common expreſſed oils of vegetables will, after their manner, freeze, that is, loſe their fluidity, and become, as it were, curdled in very cold weather, is a matter of common obſervation; but I had a mind to try, whether or no train oil, that is made of the fat of animals, (commonly that of whales) though not by diſtillation, properly ſo called, yet by the help of fire, would not be more capable of reſiſting the violence of the cold; and accordingly I found, that train-oil, expoſed to the air in a convenient phial, continued fluid, notwithſtanding a more than ordinary ſharpneſs of weather: and this I tried two or three ſeveral times, but at length one night proved ſo very cold, that the next morning I found the oil unfluid. Which differing events ſeem a little to countenance, but more to diſfavour the report of *Olaus Magnus*, who writes, that whereas in northern regions it is uſual for ſtrong places to loſe in winter the protection afforded them in ſummer, by their ditches, though never ſo wide and deep, becauſe the froſt makes them eaſily paſſable to the enemy; this inconveniency is wont to be prevented by pouring into the ditches, the ice, if there be need, being firſt broken, great ſtore of this train oil, which ſwimming upon the ſurface of the water, and being incongealable by the cold, protects the ſubjacent water from the freezing violence of the cold, and keeps the moats unpaſſable. But becauſe our author mentions this as a known and vulgar practice in thoſe icy regions, it may perhaps deſerve a little enquiry, whether the whale oil, uſed by the Swedes, Laplanders, Muſcovites, and other inhabitants of thoſe parts, be not differing, either as to the fiſhes it is made of, or as to the way of making it, or as to the way of keeping it, from ſuch train oil as we employed; unleſs perhaps it do already appear by the relation of writers belonging to thoſe countries, or of travellers, that have been in them, that *Olaus Magnus* has in that particular, as I fear he has in ſome others, miſinformed his readers.

Olaus Magnus in Hiſtoria Gentium Septentrionalium, lib. 11. *cap.* 20, *&* 21.

4. WE took notice, that a ſtrong ſolution of common ſugar was eaſily enough turned into ice; but on a ſtrong ſolution of ſugar of lead we could not with ſalt and ſnow work the like change, and this, though the trial were not negligently made: which I therefore think not unworthy to be mentioned, becauſe that the two only ingredients of this ſugar were lead, which is eſteemed a very cold body, and ſpirit of vinegar, from which, as I noted above, we did, by the like degree of cold to that we here employed, obtain ice. And though in this metalline ſugar, we may well ſuppoſe the ſaline parts of the ſpirit of vinegar to be much more concentrated or united, than they were in the ſpirit; yet the ſolution muſt abound with aqueous parts: and this ſugar ſeeming but

a kind of vitriol of lead, it is worth our notice, that its ſolution would not freeze, as well as that of common vitriol, though in this latter concrete, metal be corroded by a ſpirit, which, as far as can be judged by the liquors afforded in diſtillation, is very much ſharper and ſtronger than ſpirit of vinegar.

5. WE likewiſe tried to freeze quickſilver, and for that purpoſe provided a bubble, that being blown with a lamp, was but thin, and ſo flat, that the ſides almoſt touched, and it held but a little mercury; and that by the figure of the glaſs, being reduced to a large ſurface, with but very little depth or thickneſs, it was far more expoſed, than if it had been in an ordinary round bubble, to the action of the cold. But we could not at all freeze this extravagant liquor, though we tried it more than once, and though the laſt time we expoſed it in the ſame veſſel to the ſame degree of cold, wherewith we made one of the following experiments, that required a very intenſe degree of that quality. And in another thin glaſs-bubble we long expoſed quickſilver to an extraordinary ſharp air; but though the cold had ſome operation upon it, not here neceſſary to be mentioned, yet we could not find, that it did at all bring it to freeze. Wherefore I could wiſh that trial were made in *Muſcovy*, *Greenland*, *Charles-Iſland*, or ſome other of the moſt icy regions, where the effects of cold (which are here upon quickſilver but languid) are the moſt conſiderable, and ſometimes ſtupendous.

6. IT is very remarkable, that though not only the ſolutions of other groſs ſalt, but, as we have ſeen, divers more ſaline and ſpirituous liquors, were brought by ſnow and ſalt to congelation; yet a brine made very ſtrong of common ſalt, could not be brought to freeze at all, though we kept it expoſed with the other ſaline ſolutions, that did freeze, during a whole night, that was exceeding ſharp. Which experiment I alſo tried many years ſince, to draw thence an argument in favour of the Carteſian hypotheſis about cold, which I ſhall not now conſider; but rather add, that being deſirous to try, with what proportions of ſea-ſalt and water the congelation of them might be effected, I found, I could freeze ſome ſea-water, that had been brought up in a barrel to that monarch of the virtuoſi, the King, for the making of trials with it; and that having in a ſingle phial expoſed to the air, in a very bitter night, a ſolution conſiſting of twenty parts of water, and one of ſalt, which is double the proportion of ſalt to be commonly found in our ſea-water, the next day we found a good part of the liquor frozen, the ice ſwimming at the top in figures almoſt like broom, ſpreading from the ſurface of the water downwards. And to add that upon the by, we ſuffered the ice of ſalt water to thaw, to try, whether it would yield freſh water, but it ſeemed not devoid of ſome brackiſhneſs; which, whether or no it proceeded from ſome parts of the contiguous brine, that adhered to the ice, I leave to further and exacter obſervations, ſince I am credibly informed, that in *Amſterdam* there are divers, that uſe the thawed ice of the ſea-water to brew their beer with, inſtead of common freſh water.

3. AND ſince I made that experiment, I find in the induſtrious *Bartholinus*'s newly publiſhed book, *De Nivis Uſu*, a confirmation of the probability of the report I juſt now mentioned, his words being theſe; *De glacie ex marinâ aquâ certum eſt, ſi reſolvatur, ſalſum ſaporem depoſuiſſe; quod etiam non ità pridem expertus eſt Cl. Jacobus Finckius Academiæ noſtræ ſenior, & phyſices profeſſor, bene meritus, in glaciei fruſtis è portu noſtro allatis.* *Cap.* vi. *pag.* 42.

TITLE IV.

Experiments and obſervations touching the degrees of cold in ſeveral bodies.

1. AFTER having treated of the bodies, that are the moſt capable of producing cold, and of thoſe, that are moſt diſpoſed or indiſpoſed to receive it, it would be methodical to take notice of the *Degrees of Cold*, to be met with in differing bodies. But though a work of this nature might ſomewhat conduce to the diſcovery of cold in general, yet it is ſo laborious a taſk; and, to be well performed, requires ſo much more of leiſure, and conveniency, than I am maſter of, that I muſt reſign it to thoſe, that are better furniſhed with them. Which I the freelier do, becauſe the experiments, which at this time make the principal part of our hiſtory, being chiefly of the higheſt *Degrees of Cold*, we may ſeem to have done ſomething of what more properly concerns our preſent deſign, by having made the experiments, anon to be ſubjoined within this preſent ſection or title. And yet thus much we elſewhere do toward the framing of a table of the *Degrees of Cold*, that we do on other occaſions ſet down thoſe hitherto unpractiſed ways, that we have employed, to eſtimate the greater or leſſer coldneſs of bodies, by ſeveral kinds of weather-glaſſes, differing from the common ones, and far more fit than they, for ſuch a purpoſe. For by hermetically ſealed thermoſcopes furniſhed with high rectified ſpirit of wine, we can eſtimate the differing degrees of coldneſs in liquors, of which we ſhall preſently mention an example. And by uſing ſuch weather-glaſſes, as have their air included not at the top, but at the bottom of the inſtrument, we can, within ſome reaſonable latitude, meaſure the coldneſs both of intire ſolid bodies, or minuter bodies, as ſalts, *&c.* by beating them alike, and very ſmall, and placing the inſtruments at equal depths in the powder of each of them: and beſides, that the ſhape of theſe thermoſcopes does, as we have elſewhere ſhewn, make them proper for theſe uſes, for which the vulgar ones, where the included air is at the top of the inſtrument, are not fit; beſides this, I ſay, it is eaſy in theſe we make uſe of, to make the pipe ſo ſlender in proportion to the cavity of the phial, whereinto it is inſerted, that very much minuter differences of cold will be manifeſt in theſe, than are wont to be ſenſible in common weather-glaſſes. And beſides theſe two ſorts, we have elſewhere propoſed, and deſcribed *See preliminary diſcourſes.*

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ſcribed a third and new kind of thermometer, wherein a drop of liquor being ſuſpended in a very ſlender pipe of glaſs, betwixt the outward and the inward air, makes it far more fit for thoſe experiments, wherein we either deſpair, or care not to meaſure the difference of cold betwixt two bodies, but are only deſirous to try, whether or no they differ in coldneſs; and in caſe they do, which of them has moſt: for theſe weather-glaſſes are ſo exceeding ſenſible even of the minute difference of heat and cold, as manifeſtly to diſcover diſparities, which other thermoſcopes are not nice enough to give us any notice of. Only this advertiſement we muſt add about them, that when we uſe them to examine the coldneſs, not of liquid, but of conſiſtent bodies, we alter a little the figure of the wide end of the glaſs; and inſtead of making it a round bubble, as we have elſewhere deſcribed, we make it with a flat or flattiſh bottom, that the whole inſtrument might thereon, as on a baſis, ſtand of it ſelf upright, and ſo, being ſtill taken up by the open and ſlender end, for fear of rarifying the included air, (which caution is here given once for all) may be transferred with a pendulous drop in the pipe, and placed ſometimes on one, and ſometimes on another of the ſolid bodies to be examined by it. For if the body, it is moved to, be more or leſs cold than that it reſted on before, that coldneſs communicated through the glaſs to the air, by which the pendulous drop is ſupported, that air's expanſion or contraction will manifeſtly appear by the riſing or the falling of the drop. And thus we have taken pleaſure to remove it from one kind of wood to another, from woods to metals, and from metals to ſtones, *&c.* But the expedients, that may be propoſed to improve theſe little inſtruments to the purpoſes we have been treating of, and the cautions, that may be added to prevent men's drawing miſtaken inferences from the informations they ſeem to give them, will take up more time, than we are willing to ſpend upon an occaſion, that will not perhaps be thought to deſerve it, nor much to require any others, than thoſe we ſhall by and by ſubjoin. And therefore I ſhall proceed to the experiment promiſed at the beginning of this title or ſection.

2. To make ſo much as a tolerable eſtimate of the difference betwixt ſuch great degrees, as are not any of them too weak to congeal water, is a thing, which as we have not yet known to be attempted, ſo it ſeemed not eaſy to be performed. For freezing having been commonly reputed the ultimate effect or production of cold, men have not been ſollicitous to look beyond it. And though the diſparity we find betwixt ſeveral fits of weather, all of them froſty, ſeem to be too manifeſt and frequent to be probably aſcribed to nothing, but the differing diſpoſitions of our bodies; yet how to eſtimate that difference, it is not ſo obvious. For though we ſhould have recourſe to common weather-glaſſes, yet they might eaſily deceive us, ſince not only by eſtimating by them, the coldeſt day of one winter with the coldeſt day of another, but in judging of the coldneſs of any two days in the ſame fit of froſty weather, there intervenes time enough to make it doubtful, whether the varied gravitation of the atmoſphere produce not the change obſerved in the weather-glaſs. Beſides that, admitting vulgar thermometers could not, as they eaſily may, miſ-inform us, they are employed only to give us an account of thoſe degrees of cold, which nature, of her own accord, produces in the air; but not to diſcover, whether or no nature, aſſiſted by art, may not produce greater: and, it will eaſily be granted, that they are yet leſs made uſe of to help us to an eſtimate of this diſparity. And though ſome gueſs may be made by the operations of cold upon liquors expoſed to it, yet ſome, as water, and very aqueous liquors, will freeze too ſoon, and others, as vinous ſpirits, will not at all, (that we have found) here in *England*. And though French wine will ſometimes be brought to begin to freeze, yet that happens but very ſeldom, and in many winters not at all, and leaves too great an interval betwixt the degrees neceſſary to congeal wine, and ſufficient to congeal water; not to mention the uncertainty proceeding from the differing ſtrengths of the wines.

3. Upon theſe and other conſiderations, we thought it requiſite to make uſe of an expedient, whoſe nature and uſe will be eaſily gathered out of the following experiments: and though by a miſchance, that broke my weather-glaſs, I have been hindered from meaſuring exactly in what proportion to the whole bulk the ſpirit of wine was contracted, by the ſurpluſage of cold, that was more than neceſſary to make water freeze, yet I doubt not but ſomething of uſe to our preſent theme, may be thence collected, and eſpecially the main thing deſigned will manifeſtly appear, which is the intenſity of cold produced by art, beyond that, which nature needs to employ upon the glaciating of water.

[4. A Small ſealed weather-glaſs furniſhed with ſpirit of wine, the ball being about the bigneſs of a ſmall nutmeg, and the cylindrical ſtem being very ſlender, and about ten inches long, the ball and part of the ſtem being immerſed in a veſſel of water, half buried in ſnow and ſalt, when the water began to freeze at top, the bottom and the ſides, (but before the ice had reached the ball, for fear it ſhould break it) the tincted liquor was found ſubſided to $5\frac{2}{3}$ diviſions, being half inches; and being taken out thence, and ice and ſalt being immediately applied to the ball, the liquor fell lower to about $1\frac{1}{2}$ diviſion.]

And that it may not be doubted, but that the water, though in part congealed, remained warm in compariſon of the ſpirit of wine, though uncongealed, that had been refrigerated by the ſnow and ſalt, we will add this other experiment, which we find in another of our notes thus ſet down.

[5. The ſealed weather-glaſs being kept in the water till it began to freeze, deſcended to $5\frac{1}{2}$: being immediately removed into the ſame ſnow and ſalt, that made the water begin to freeze, it deſcended at the beginning very faſt, and afterwards more ſlowly, till it came to the very 4. *Jan.* 15.

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very bottom of the ſtem, where it expands it ſelf into the ball; then being removed into the ſame glaſs of water, whence it was taken, and which was well ſtored with looſe pieces of ice, it did nevertheleſs haſtily aſcend at the beginning, and was ſoon after impelled to the former height of five diviſions and an half, or thereabouts.]

6. BUT perhaps ſome amends may be made for the diſaſter of the weather-glaſs, by adding, that I found by another trial, that the condenſation of liquors by ſuch colds, as we are wont to have, or can eaſily produce here, is nothing near ſo great as one would imagine. And though for want of a glaſs-ball, furniſhed with a neck ſlender enough, I could not make the experiment ſo much to my ſatisfaction, as perhaps elſe I might have done; yet the goodneſs of the ſcales I made uſe of, and ſome greater care, than poſſibly every experimenter would have employed, may make the following obſervation luciferous.

7. WE took then (on a cold, but not froſty day) oil of turpentine, as a liquor, whoſe being free from phlegm or water we could eaſily be more certain of, than if we had employed ſpirit of wine; and this oil itſelf we rectified in a gentle heat, to make it the more pure and ſubtile. Then we took a ſmall round veſſel of clear glaſs furniſhed with a conveniently long ſtem or pipe, and having firſt weighed the glaſs alone in a pair of very good ſcales, we found it to weigh ℥i. ʒi. 56 ½ gr. Then putting in oil of turpentine, till it filled the round part of the glaſs, and aſcended a little way into the ſtem, we carefully marked with a diamond on the outſide of the glaſs, how high it reached, and then weighed the glaſs and the oil together, which weighed ℥ij. ʒvij. and 34½ gr. Then we put in, by degrees, a quarter of a drachm, and with a diamond carefully marked, how high it reached in the pipe, and ſo we continued putting in ſeveral quantities of oil, ſtill carefully weighing each parcel in the ſcale, and marking its height on the outſide of the glaſs (which we did in order to a certain deſign, and found it a work tedious and troubleſome enough) till the liquor and the glaſs together weighed ℥iij. ʒi. 4½ grains. Then we put fair water into an open-mouthed glaſs, in which we alſo placed the little bolt-head with oil of turpentine, and by ſuch a circumpoſition of ſalt and ſnow, as is * hereafter to be often mentioned, we made the water, which was contained in the wide-mouthed glaſſes, and by which the ſpherical part of the bolt-head, containing the oil, was ſurrounded, we made this water, I ſay, begin to freeze; and when we perceived a little ice to be produced in it, we carefully marked with a diamond, to what part of the ſtem the oil of turpentine was ſubſided, and then tranſferring the bolt-head into a mixture of ſnow and ſalt, where we kept it for an hour or two, till we could perceive it to fall no lower, and marking with a diamond, this ſtation alſo of the liquor, we afterwards removed the glaſs into a warmer air, till the oil, by expanding it ſelf, had regained the higheſt mark, whence it had begun to ſink. Then into a very little glaſs, carefully counterpoiſed in a pair of exacter ſcales than the former, we gently poured out of the oil, till what remained reſted againſt that mark on the outſide of the ſtem, to which it fell, when the water began to freeze: and this we found to amount to ſomewhat above 9½ grains; ſo that, for conveniency of reckoning, we may ſafely enough take the intire number of 10 grains. After this, we poured out of the remaining oil into the ſame little glaſs, till what reſted in the pipe was even with that mark, to which the ſnow and ſalt had made it fall; and this parcel of oil happened to be almoſt preciſely of the ſame weight with the other: ſo that in this trial (for perhaps in others, which it were therefore worth while to make, the degree of cold may much vary the events) the artificial way of freezing we employed, made the oil ſubſide as much after it had been refrigerated and condenſed by a cold capable of freezing water, as that degree of cold had been able to condenſe it at firſt. And laſtly, having deducted the weight of the glaſs from the weight of the whole oil and glaſs, to obtain the weight of the oil alone; and having divided the weight of the whole oil, firſt, by that of the former parcel, we have mentioned to be ten grains, and then by the ſuperadded weight of the ſecond parcel, we took out, (both which parcels together we eſtimated at twenty grains,) we found that rectified oil of turpentine of a moderate temper, being expoſed to ſuch a degree of cold, as would freeze common water, did, by ſhrinking, loſe but about a ninety-fourth part of its bulk; and being reduced to as great a degree of cold as we could bring it to by ſnow and ſalt, even then it loſt but about a forty-ſeventh part of its bulk: I ſay about, becauſe I thought it needleſs, as well as tedious, to mind fractions and little odd numbers; eſpecially ſince, as we formerly intimated, it was ſcarce poſſible to arrive at a great exactneſs in ſuch a neck as that of our bolt-head, though it were proportionable enough to the ball, and choſen among ſeveral, that were purpoſely procured for the trying of experiments.

8. THERE are ſome other trials about the degrees of cold, which for want of ice and other accommodations we could not make, as we would have done often; nor ſhall ſcarce be able to do it, till more friendly circumſtances afford us an opportunity: and yet becauſe our trials, though not proſecuted as far as we thought, may poſſibly prove not unwelcome, yet we will ſubjoin ſomething about two of the chiefeſt of them.

9. THE one was deſigned to meaſure in what proportion water, of a moderate degree of coldneſs, would be made to ſhrink by the circumpoſition of ſnow and ſalt, before it begin by congelation to expand itſelf: of this, what we ſhall here take notice, is only, that by a trial purpoſely made with common water, in a round glaſs furniſhed with a long ſtem, we found the water in that ſtem to ſubſide ſo very little, that, whether or no it were inſenſible, it was inconſiderable. But probably a greater quantity of water, and a ſlenderer ſtem, would have

* *See the latter part of the next title.*

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have made the ſhrinking of the liquor more notable, and upon that account it is, that I here mention it.

10. THE other thing was, to meaſure by the differing weight and denſity of the ſame portion of water, what change was produced in it, betwixt the hotteſt time of ſummer, and firſt a glaciating degree of cold, and then the higheſt we could produce by art. And in order to this, we weighed with a pair of exact ſcales, a glaſs bubble heavier than water, in that liquor, when it ſeemed to be at a moderate temper, as to coldneſs, and by the diminution, which we found of the glaſs's weight in the water, we eaſily collected, according to the rules of the hydroſtaticks, the weight of as much water, as is equal in bulk to the glaſs bubble, and thereby the proportion betwixt the glaſs and an equal bulk of ſuch water, as we firſt weighed it in: then by the application of ſnow and ſalt, we made that water begin to freeze, and weighing in it again the ſame bubble, it was eaſy to collect, by the decrement of its weight in this refrigerated water, what proportion an equal bulk of the liquor did then bear to the glaſs: and by comparing theſe two differing proportions together, we were aſſiſted to make an eſtimate, how much the water was made more heavy and denſe by the action of a freezing degree of cold. Afterwards taking our time in ſummer, we thought fit in the ſame parcel of water (that had been purpoſely reſerved in a glaſs) to weigh the ſame bubble, that by the difference of its weight in the water, when made much lighter by the heat of the ambient air, we might obtain the information we deſired. To which we ſhall add, that we alſo recommended to ſome Virtuoſi, that were likely to have the opportunity of gratifying us, that ſuch an experiment might be procured to be made in the midſt of ſummer in ſome part of *Italy*, by the help of the there not unfrequent conveniency of a conſervatory of ſnow, wherein the water might be reduced to freeze before the end of the ſame hour, at whoſe beginning the there warmer air had given it its greateſt expanſion, and ſo the difference betwixt the denſity of the ſame parcel of water might be the more conſpicuous. But as I have not received any account of my deſires from abroad, ſo coming now at home to review the memorial, I cauſed to be written of the newly mentioned obſervation, I find, that through the negligence or miſtake of an *Amanuenſis*, there muſt needs be a manifeſt overſight committed in the ſetting down the numbers which my memory does not now enable me to repair. And the ſeaſon being now improper to repeat the experiment, as well as the numerical parcel of water I had kept, and I employed both times, being thrown away, I think it may be ſufficient, if not too much, to have thus particularly intimated the way we took, without adding the cautions, wherewith we proceeded, nor what trials we made to the ſame purpoſe with high rectified ſpirit of wine, ſince unlucky accidents fruſtrated our attempts.

11. WHETHER the making of theſe kind of trials, with the waters of the particular rivers or ſeas, men are to ſail on, may afford any uſeful eſtimate, if, and how much, ſhips and other veſſels, may on thoſe waters be ſafely loaden more in winter than in ſummer, may be an enquity, of which I ſhall not in this place take any further notice, than to intimate thus much, that the difference betwixt water highly refrigerated, and that which is but of an uſual degree of coldneſs, is not ſo great, as ſome learned moderns ſeem to have thought. For on a day, which (though made cold by ſnow intermingled with the rain that then fell) was not a froſt, we took common water, and weighed it in a glaſs bubble, whoſe weight in the air was 150 grains, and this bubble, weighed in that water, loſt ſo much of its former weight, as to weigh about $28\frac{5}{6}$ grains: and then by ſnow and ſalt, reducing that water to ſuch a degree of coldneſs, that it began to be turned into ice about the inſide of a ſmall open glaſs that contained it, we found the ſame bubble not to weigh at all above one eighth part of a grain leſs than it did before. So that if we may judge of the ſhrinking and condenſation of the water by the increment of weight, it ſhrunk but about a 230th part of its former bulk, and this according to a pair of ſcales, that would turn with about the 32d part of a grain: which may keep us from wondering at what we lately delivered concerning the very inconſiderable ſubſidence of the water, we expoſed to ſnow and ſalt in a ſmall bolt-head. And it may alſo make that the more probable, which we not long ſince related about the oil of turpentine's not loſing much above a 100dth part of its bulk, by being expoſed to ſuch a degree of cold, as made water begin to freeze. Whether we may from this, and from the formerly recited experiment, of the great ſubſidence of ſpirit of wine in a ſealed weather-glaſs, ſafely conclude, theſe ſubtile diſtilled liquors to be much more ſenſible than waters of cold, as well as of heat, further trials will beſt reſolve: and theſe I have not now ſo much opportunity, as I could wiſh, to purſue.

12. BUT they that have a mind to proſecute experiments of this kind, and others, that relate to the degrees of cold, may perchance be ſomewhat aſſiſted even by theſe relations, and eſpecially by thoſe paſſages, that mention the uſe of the ſealed weather-glaſs, furniſhed with ſpirit of wine, and of thoſe wherein a drop of liquor is kept pendulous. For the former of theſe being not ſubject to the alterations of the atmoſphere's gravitation, (nor, as may be probably ſuppoſed, by reaſon of the ſtrength of the high rectified ſpirit of wine) to be frozen, by ſending the ſame weather-glaſs (which may be portable enough, as I have tried by tranſporting one of them in a caſe, that might be eaſily carried even in a pocket) from one country to another, one may make far better diſcoveries of the differing degrees of coldneſs in differing regions, and know (ſomewhat near) how much the air even of *Muſcovy*, or *Norway*, or *Greenland* itſelf, is colder than that of *England*, or any other country, whence the weather-glaſs ſhall be ſent: the inſtrument being accompanied

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with a memorial of the degree, it ſtood at, when expoſed to ſuch a cold, as made water begin to freeze.

13. THE other thermometer, where a drop of liquor is kept pendulous, may not only be employed in ſuch caſes, where the pipe and bubble can be erected upon the horizon, but by reaſon, that the outward air will indifferently impel the bubble laterally or upwards, upon the refrigeration of the inward, and that the bubble will not barely by its weight drop out of the inverted inſtrument, becauſe of the reſiſtance of the ſubjacent outward air; for theſe cauſes, I ſay, ſuch a thermoſcope may, as we have tried, be alſo uſed, where the pipe ſhall be held horizontal, or inclined, or even perpendicularly downwards, ſo that the flat part of the bubble may be applied to diſcover the coldneſs either of the wall, or of the ceiling of a room, or other bodies however ſituated. And if the pipe be made long and even, (as ſometimes we employ one above a foot long) not only ſenſible, but great effects of very little diſparities in the coldneſs of bodies, to which the inſtrument is applied, may with pleaſure be obſerved. And the ſame drop of liquor may be long enough preſerved uſeful in the pipe. But this advertiſement I ſhall give, that as ſenſible as this inſtrument appears to be of the nicer differences of coldneſs, as of heat, yet they, that ſhall have the curioſity to examine with it, as I have done, the temperature, I ſay not, of more reſembling bodies, but of liquors, that may be thought to have their parts ſo differingly agitated, as common water, high rectified ſpirit of wine, and even rectified oil of turpentine, (I add not dephlegmed oil of vitriol, becauſe of ſome odd phænomena not here to be inſiſted on) will perhaps find the event ſo little, in many caſes, anſwer the expectation he would have had of uniformly finding great diſparities in their actual coldneſs, if he had not met with this advertiſement, that he will not much wonder, that a perſon, who wants not other employments for his time, was willing to decline ſo tedious and nice a taſk.

TITLE V.

Experiments touching the tendency of cold upwards or downwards.

1. THOUGH, after the conſideration of the ſphere of activity of cold, it would be the moſt proper place to take ſome notice of the direction of its activity, yet, becauſe one of the experiments, that belong to this head, is of great uſe to facilitate the trial of many of thoſe, that follow, throughout this whole collection; we will no longer delay to ſay ſomething of this matter, namely, in what line, or, if you pleaſe, towards what part the frigefactive virtue of cold bodies does operate the furtheſt and the moſt ſtrongly.

2. IT is a known doctrine among philoſophers, that the diffuſion of heat tends chiefly upwards, as the flame of a candle will burn many things held over it at a greater diſtance, than it would conſiderably warm them at, in caſe they were held beneath its level, or even by its ſides: and it is true, that in all caſes vulgarly taken notice of, the obſervation, for reaſons elſewhere diſcourſed of, holds well enough; and therefore it may be worth enquiry, whether in cold, which is generally looked upon as the contrary quality to heat, the diffuſion (from cold bodies) be made more ſtrongly downwards, than either upwards or towards the ſides.

ABOUT this matter, I can as yet find among my notes but the two following experiments, and thoſe not both together.

[A VERY thin bubble was blown at a lamp, and purpoſely made flat at the bottom, that it might be the more expoſed to the cold, and it was ſuſpended by a ſtring within a pretty deal leſs than an inch of a mixture of beaten ice and ſalt, wherewith we had half filled a conveniently large wide-mouth'd glaſs; but we could not find, that a cold, capable of freezing, did ſtrike ſo high upwards, for the water in the bubble remained altogether unfrozen; which agrees very well with what we have obſerved, that a mixture of ice and ſalt did not congeal the vapours, that wandered through the air, above half a barley-corn's breadth higher, than the mixture in the glaſs reached.]

3. [A MIXTURE of ſnow and ſalt being put into a phial with a long neck, the round part of it was by a weight kept under water, out of which being taken after a while, the outſide of the glaſs beneath the ſurface of the water was caſed with ſolid ice, *N. B.* eſpecially about the bottom of the phial, of greater hardneſs and thickneſs than any one could eaſily imagine.]

4. THUS far the notes, from which nevertheleſs I will not poſitively conclude, though they ſeem to perſuade it, that the tendency of the cold produced by bodies qualified to freeze others is greater downwards than upwards: for the ſatisfactory determination of that matter may, for aught I know, require trials more artificial and nice, than thoſe we have been reciting. And I could wiſh, that I could find the laſt of them to have been carefully repeated and regiſtered, becauſe it ſeems ſomewhat ſtrange, that the ice ſhould be much thicker at the bottom of the phial, than elſewhere; in regard that when we have, as we very frequently have, put mixtures of ſnow and ſalt into phials, and left them in the open air, we generally obſerved, that the outſide of the glaſs was caſed with ice, or covered with hoar froſt, directly over againſt that part of the inſide of the glaſs, wherein the frigorifick mixture was. So that part of the ſnow and ſalt reſolving one another, and falling down in the form of a liquor to the bottom, the unmelted part of the mixture would float upon this liquor, and the external ice would appear over-againſt the floating mixture, by which it was generated: ſo that as the mixture grew thinner and thinner, ſo would the zone or girdle, if I may ſo call it, of external ice, grow narrower and narrower, till at length, when the ſnow was quite melted away, the external ice would quickly alſo vaniſh. But from this obſervation (which we frequently made) that as in ſuch phials the ice did not appear (as I juſt now related) above half

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half a corn's breadth higher than the mixture in the glaſs; ſo I remember not to have obſerved it much lower beneath the mixture: from thoſe things, I ſay, it may be probably conjectured, that even the coldeſt bodies (at leaſt unleſs their bulk alter the caſe) do not diffuſe their freezing virtue, either upwards or downwards to any conſiderable diſtance.

5. THESE trials, as I was intimating, may ſuggeſt ſome difficulties about the laſt of the two experiments, tranſcribed out of my notes. But as it is evident theſe obſervations were made in the open air, by the freezing of its roving vapours, and the mentioned experiment was made under water; ſo how much this difference of mediums may alter the caſe, as to the way of the diffuſion of cold, I dare not, till further trial, boldly determine: eſpecially ſince one circumſtance, to be under the next title mentioned, about the freezing of eggs, may paſs for an additional experiment as to our preſent inquiry. For the caſes obtained by frozen eggs ſuſpended under water ſeem to argue, that the diffuſion of their cold was made every way, ſince they were quite incloſed inthe ice, they had produced.

6. THOUGH the experiment of freezing water, by the intervention of ſalt and ſnow, be not a new one for ſubſtance, yet I hold it not amiſs, to make a further mention of it on this occaſion. Becauſe that what I am to deliver about it, is a particular not taken notice of (that I know of) by others; the premiſing of which will, according to what we lately intimated, much facilitate the trial of many of the experiments to be ſet down in the following part of theſe papers, and will indeed appear to be of no ſmall moment in our whole attempt of framing an *Hiſtory of Cold*. For it has long ſeemed to me one of the chief things, that has hindered men from making any conſiderable progreſs in this matter, that whereas glaſs-veſſels are generally much the moſt proper to freeze liquors in, becauſe their tranſparency allows us to ſee, what changes the cold makes in the liquors expoſed to it; the way of freezing with ſalt and ſnow, as it has been hitherto uſed, does almoſt as little, as the common way of barely expoſing veſſels to the cold air in froſty weather, prevent the unſeaſonable breaking of the glaſſes. For in both theſe ways, the water or other liquor uſually beginning to freeze at the top, and it being the nature of glaciation, as we ſhall ſee anon, to diſtend the water and aqueous liquors it hardens, it is uſually and naturally conſequent, that when the upper-cruſt of ice is grown thick, and by reaſon of the expanſion of the frozen liquor bears hard with its edges againſt the ſides of the glaſs contiguous to it, the included liquor, (that is by degrees ſucceſſively turned into ice) requiring more room than before, and forcibly endeavouring to expand it ſelf every way, finds it leſs difficult to burſt the glaſs, than lift up the ice; and conſequently does the former, and thereby ſpoils the experiment, before it be come to perfection, or have let us ſee what nature would have done, if ſhe had not been thus hindered in her work.

7. THE conſideration of this invited me to alter the common way of freezing, and order the matter ſo, that whenſoever I pleaſed, the expoſed liquor ſhould not begin to freeze at the top or ſides, but at the bottom; which I concluded it very eaſy to do, by mingling the ſalt with that part only of the ſnow, which was to lie beneath and about the bottom of the glaſs I placed in it. For by this means the ſnow, that was contiguous to the ſides, was able but to cool the water, and diſpoſe it to glaciation; whereas the mingled ſnow and ſalt, on which the bottom of the glaſs reſted, did actually turn the neighbouring liquor into ice, and lift up the incumbent liquor towards the higher and empty parts of the glaſs. And this liquor alſo I could afterwards freeze at pleaſure, without danger of breaking the veſſel, only by ſo applying ſalt and ſnow to the ſides of the glaſs, that they never reached, except perhaps at the very concluſion of the experiment, ſo high by a reaſonable diſtance, as the upper ſurface of the liquor in the glaſs; ſo that the ſuperiour parts of that liquor were always kept fluid, and capable of being eaſily impelled higher and higher, by the expanſion of the freezing parts of the ſubjacent liquor.

8. THE ſpeculative inference, that may be drawn from this experiment, of making water begin to freeze at the bottom, not the top, will be more properly taken notice of in another place: in the mean time, I ſhall only intimate by the way, that there is no great neceſſity of any nice proportion of ſalt to ſnow, nor of any exquiſite mixture of them: a third or fourth part, or thereabouts, of ſea-ſalt, in reference to the ſnow, will not do amiſs; nor do I uſually put ſalt to all the ſnow at once, unleſs in ſome caſe, wherein I have a mind to freeze a liquor quickly, and make a ſpeedy reſolution of the ſnow and ſalt in order thereunto. To which I ſhall only add, that by the way abovementioned, I do upon particular occaſions make the expoſed liquor freeze, not at the bottom or the top, but next to what ſide of the glaſs I pleaſe, according to the exigency of the experiment. But though it may ſuffice to have hinted the ſpeculative inference, that may be drawn from this way of freezing liquors, it will be expedient to give explicitely this practical advertiſement concerning it; that whereas it ſeems to have been taken for granted, that ſnow is neceſſary in this artifice, and we our ſelves were for ſome time led away with the reſt by that ſuppoſition; yet that is but a preſumption, and ought to be removed, as one very prejudicial to thoſe, that with us deſign the proſecuting experiments, in order to the *Hiſtory of Cold*. For ſnow is but ſeldom to be found on the ground in compariſon of ice, and being but a congeries of many ſmall icicles, with much air intercepted among them, it is not (*cæteris paribus*) near ſo durable, as the more intire body of ſolid ice. And yet we have found by frequent experience, that ice, well beaten in a mortar, will ſerve our turn for artificial glaciations, as well (if not in ſome reſpects better) as ſnow; and therefore in this *Hiſtory of Cold* we indifferently preſcribe ſnow

In the diſcourſe touching the *primum frigidum*.

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and ſalt, or ſalt and ice, as the ingredients of our glaciating mixtures.

TITLE VI.

Experiments and obſervations touching the preſervation and deſtruction of (eggs, apples, and other) bodies by cold.

1. IT is a tradition common enough, though not here in *England*, yet among thoſe, that have given us accounts of very cold countries, that if eggs or apples, being frozen, be thawed near the fire, they will be thereby ſpoiled; but if they be immerſed in cold water, the internal cold will be drawn out, as they ſuppoſe, by the external, and the frozen bodies will be harmleſly, though not ſo quickly thawed. This tradition I thought fit to examine, not only becauſe it may be doubted, whether it will ſucceed in our more temperate climate, and becauſe I love not to rely upon traditions, when I have the opportunity to examine them (eſpecially if no one credible author affirms them upon his particular knowledge,) but alſo becauſe I thought the experiment, if true, might be ſo varied and made uſe of, as to become luciferous enough, and afford us divers phænomena of cold, not ſo eaſy to be produced by the more known ways of experimenting. And accordingly having expoſed ſome of theſe bodies to a cold, that was judged ſharp enough, we afterwards put them in water, but found not the event anſwer our expectations, no ice appearing to be generated: nevertheleſs we were not hereby ſo diſcouraged, as not to repeat the experiment (which we judged to be not unlikely) with more ſollicitouſneſs and advantage than before; and having thereby brought it to ſucceed, we afterwards made ſeveral trials of it with ſeveral diſtinct aims, but cannot now find any entry of divers of them. But thoſe I have hitherto met with among my notes, I ſhall ſubjoin, as having in them ſome particulars, that may afford uſeful hints to an inquirer into the hiſtory and nature of cold. And I ſhall ſet down together, and that in this place (though it would not otherwiſe be the moſt proper) thoſe I have met with, becauſe ſome circumſtances of one or other of them may be of uſe to us on ſeveral occaſions in the preſent treatiſe.

2. [AN egg weighing twelve drachms and one grain wrapt in a waxed paper (to keep it from the liquor of the thawing ſnow) and frozen with ſnow and ſalt, wanted four grains of that weight: put into a diſh of fair water, there crufted as much ice about the outſide, as made the egg and ice fifteen drachms and nine grains. The ice being taken off from the ſhell, and the ſhell very well dried, the egg was found to weigh twelve drachms and twelve grains; the egg being broken, was found almoſt quite thawed; the egg frozen ſwam in water; being thawed, it ſunk.]

3. [WE took two eggs ſtrongly frozen, and in a room, where there was a good fire, we put one of them into a deep wooden diſh full of very cold water, and ſet the other by it, upon a table about two yards from the fire, that they might be in air, of the ſame temper as to heat and cold; then perceiving the egg, that lay under water, to have obtained a thick cruſt of ice, we took it out; and having firſt freed it from the ice, broke it, and found, that ſome part of the white was not yet freed from a pretty ſtore of little parcels of ice, but the reſt of the white (which was much the greater part) and the yolk ſeemed to be much-what of the ſame conſiſtence, as if the egg had not formerly been frozen; whereas the other egg, that lay by upon the dry table, had not only its whole white frozen into a conſiſtent body, but the yolk it ſelf, though we ſaw no diſtinct particles of ice in it, was grown ſo hard, that it cut juſt like the yolk of an egg over-boiled; and being cut quite through, ſhewed us certain concentrical circles of ſomewhat differing colours, with a ſpeck much whiter than any of them in the middle of the yolk; which laſt circumſtances, whether they were accidental or no, further obſervation muſt determine.]

NOTE, that though we have not found above once, that frozen eggs would ſwim, yet when we had broken ſuch eggs, the frozen white would ſwim, but not the yolk.

4. WE afterwards repeated the experiment of laying two frozen eggs near together in the place above mentioned, the one under water, and the other out of it, till that put in water had got a thick icy cruſt, and by breaking of them both, preſently after one another, were confirmed in the perſuaſion, that frozen eggs will thaw by great odds (*cæteris paribus*) faſter when immerſed in water, than when ſurrounded only with air.

5. [WE likewiſe took a frozen egg, and from a fixed place ſuſpended it ſo by a ſlender packthread, that it hung quite under water, without yet touching the veſſel, that the water was in. This we did partly upon another deſign, and partly to obſerve, whether or no the ice would in this caſe be conſiderably thicker or thinner againſt the lower parts of the egg, as we formerly mentioned our ſelves to have obſerved it to be very manifeſtly at the lower parts of a glaſs, which having ice and ſalt in it, was immerſed under water; but when we took out the egg, after we ſaw, that its icy caſe had covered the packthread it was hung by, we found the caſe, upon breaking it, of a thickneſs uniform enough to keep us from concluding any thing from this trial; ſince, though there were a pretty deal of ice generated at ſo ſmall a diſtance from the caſe of the egg, that it ſeemed to owe its production to the ſame cauſe, yet, which was ſomewhat odd, we did not find, that this ice ſtuck to that, which did immediately embrace the egg, though we had ſome faint ſuſpicion, that the rudiments of it might have been very early parted from the egg, by ſome little ſhaking of the table, occaſioned by people's paſſing to and fro in the room.]

6. [WE took ſome pippins, and expoſing them to freeze all night, and putting them the next morning into a baſon of very cold water (though in a warm room) they were not long there without being incloſed with caſes of

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ice of a conſiderable thickneſs. Where note, 1. That that part of a floating apple, that was immerſed under water, had a very much thicker coat than the other part, which remained above it. 2. That the extant part ſeemed likewiſe to be harder than the immerſed. 3. That one of theſe pippins being purpoſely left out of the baſon, but laid by it, ſeemed, upon cutting, to be harder and more frozen than thoſe apples, which had been put into the water; which ſcarce ſeemed to be at all harder than ordinary pippins, that had never been ſet to freeze, at leaſt as to thoſe parts of the apples, that were near the rind, and conſequently near the ice. 4. That neither frozen pippins nor frozen eggs, notwithſtanding their great power of turning part of the contiguous water into ice, did appear to us to detain or congeal any of the roving vapours of the air, as ice or ſnow included with ſalt in glaſſes is (as we have formerly obſerved) accuſtomed very remarkably to do.]

[7. We took eggs, and froze them with ice and ſalt, till the ſhells of them were made to crack: then we took them out, and put one of them in milk, two of them in a wide drinking-glaſs full of beer, and two more in a large glaſs, wherein we covered them with ſack, that was poured in till it reached much higher in the glaſs than the eggs. But none of theſe trials produced, as we could perceive, one grain of ice.] And being deſirous to ſee, whether the acid ſalt of vinegar, or the cold in a well-frozen egg, would have the chief operation, if thoſe two bodies were put together; I found upon trial, that the ſaline parts of the vinegar began to diſſolve the egg-ſhell, as appeared by the much altered colour of it, but the cold of the ice in the eggs was not able to freeze any part of the water or phlegm of the vinegar.

8. We had alſo thoughts of trying, whether or no pieces of iron of ſeveral ſhapes and bigneſſes, being for divers days and nights expoſed to the freezing air, and afterwards immerſed in water, would produce any ice, as frozen eggs and apples do. For the brittleneſs of the laths of ſtone-bows in ſharp froſts, together with other obſervations elſewhere mentioned, ſeem to argue, that (to uſe a popular phraſe) the froſt does alſo get into theſe bodies. And I have been aſſured by one, whom the trials I had made with eggs and apples, invited me to conſult, that a great cheeſe he immerſed in water in a cold country, was preſently covered over with ice. But though, as I ſaid, I had thoughts of making the abovementioned trials, yet for want of a froſt ſufficiently durable, I was not able to effect what I deſigned. But thus much I tried, that though I kept good lumps of iron, and, as I remember, of other metals, beſides pieces of glaſs, and a ſtone or two of a convenient ſize, in ſnow or ſalt, I know not how much longer, than would have ſufficed to make eggs or apples, or ſuch kind of things, fit to produce ſtore of ice in water, upon their being thawed therein; yet we could not find, that upon the immerſing the ſeveral newly named mineral bodies, there was the leaſt ice produced in the cold water, where we kept them covered. I muſt not, nevertheleſs, omit to make ſome mention of that, which lately ſeemed to happen at the door of our own laboratory, (reſpecting the north eaſt) where ſome glaſſes, newly brought from the ſhop, and not imployed, lying in a baſket, as they poured water into one of them to rince it, part of it was preſently turned into ice, whilſt one of my domeſticks held it in his hand; who coming preſently to ſhew it me, I ſuſpected the ice might have come from, or rather with the water, that was poured into the glaſs, but upon inquiring was aſſured of the contrary.

9. But here I muſt not omit another trial relating to the former experiments, which may ſeem ſomewhat odd, if its event prove conſtantly the ſame, as when we tried it. For after theſe and divers other experiments made with frozen eggs and apples, we thought it might be worth the examining, whether or no ice and the liquors of theſe concretes would produce the like effects, as frozen eggs and apples. And becauſe it is uſually an eaſier way than that, which is more common, of bringing bodies, whoſe degree of cold is more languid, to freeze water, to include them with ice or ſnow in a ſingle phial, and ſo put them upon acting only upon the minute, and eaſily congealable vapours, that wander in the air; we took that courſe in the trials we are mentioning: whoſe ſucceſs is thus briefly ſet down in one of our notes.

[10. Ice and juice of pippins, well ſhaken together in a ſingle phial, produced abundance of dew; but we could not ſatisfy ourſelves, that it produced any ice.]

[11. Alſo ice and the white of an egg, moderately beaten into a liquor, were tried, with juſt the like ſucceſs; but theſe trials having ſcarce been made above once, and at moſt but twice, are to be repeated.]

12. As for what is ſaid, that eggs and apples thawed in the water are better preſerved than thawed by the fire's ſide; we tried it in pippins, (for in eggs the experiment is not ſo eaſily and quickly made) and, as far as we could diſcern, found it true, and ſomewhat wondered to ſee, how ſoon, and how much putrefaction was induced into thoſe looſely contexed bodies by an overhaſty thawing.

13. If we may believe the relations of navigators, and others of good credit, (of one or two of whom I had the opportunity to make inquiry) there may be good uſe made of what happens in the different ways of thawing eggs and apples, by applying the obſervation to other bodies, and even to men, that happen to be dangerouſly nipped by exceſſive cold. For it is a known obſervation among thoſe, that have inhabited or viſited the northern climates, that if thoſe, whoſe hands or feet, or faces happen to be frozen, approach them too near or haſtily to the fire, they are in danger of loſing, or at leaſt much prejudicing the overhaſtily thawed parts. 'Upon divers of us, (ſays Captain *James*, ſpeaking of his companions) 'had the cold raiſed bliſters as big as 'walnuts.

'walnuts. This we imagined to come, by 'reaſon that they came too haſtily to the fire.' And therefore they, that are more careful to be ſafely than quickly delivered from the painful cold, are wont, before they come near the fire, whether it be open or in ſtoves, either well to waſh their hands, or other frozen parts, in very cold water, or elſe to rub them well with ſnow it ſelf. And this brings into my mind, that I ſometimes endeavoured to find by trial, what beef long expoſed to freeze and differingly thawed would teach me, by way of confirmation of this tradition; but being then obliged to unſeaſonable removes from the place, where I made my trials, they did not for that reaſon afford me the ſatisfaction I deſired; but meeting with an intelligent perſon, that had been an houſekeeper in *Muſcovy*, and enquiring of him, whether he had obſerved any thing about this matter, he told me, that having once had two very large cheeſes frozen, he thawed one of them into water, and the other in a ſtove, but found, that thawing in water was much the better way of the two. And I was well pleaſed to be anſwered by him, that the cheeſe, thawed in water, did ſoon acquire therein a cruſt of ice.

14. BUT more memorable is that relation, which I remember I have read in the experienced chirurgeon *Fabricius Hildanus*'s treatiſe of *Gangrenes*, where he relates from credible teſtimony, how the whole body of a man was ſucceſsfully thawed, and, which is more ſtrange, caſed all over with ice, by being handled as our eggs and apples were. His own words, becauſe the narrative may prove of ſome uſe, I ſhall ſubjoin, and they are theſe: *Narravit mihi vir quidam nobilis & fide dignus, ſe, cum eas regiones peragraret, incidiſſe aliquando in viatorem ſecundùm viam frigore rigidum, ac pene mortuum, quem plauſtro ſuo impoſitum, cum deduxiſſet in diverſorium, hoſpes illico demerſit in frigidam, quo facto undequaque ita erupit gelu, ut ipſius corpus glacie, ſeu ferreo thorace contectum conſpiceretur. Tum quoque propinatum illi ajebat cyathum ampliorem hydromelitis, quo illi ſeu potu ordinario utuntur, addito pulvere cinnamomi, caryophillorum, & macis, unde ſudor in lecto provocatus eſt; atque ita ægrum ad ſe rediiſſe amiſſis duntaxat manuum & pedum extremis articulis. Hinc intelligimus hanc methodum ſanandi congelatos veram ac tutam eſſe, ac eam etiam probat ſummus philoſophus, qui regiones illas frequentavit*, &c.

Guli elmus Fabricius Hildanus de Gangr. & Sphacelo, Chap. 10.

15. THE experiment delivered at the beginning of this title, (of ſpeedily producing ice on the outſide of frozen eggs and apples, by immerſing them in cold water) I take to be one of the two or three moſt illuſtrious, I have hitherto met with about congelation; and as likely as any to aſſiſt us to inveſtigate the cauſes of it. But though the phænomena ſeem very favourable to their hypotheſis, that ſuppoſe congelation to be effected by the ingreſs of frigorifick atoms into the water or other bodies to be congealed; yet (for ſome reaſons) I ſhall not here offer to draw any ſpeculative inference from the experiment, contenting my ſelf to have here, and at the beginning of this ſection, hinted *in tranſitu* the hopefulneſs of its proving luciferous.

16. BUT I remember, that the title of this ſection promiſes ſomething concerning the preſervation and deſtruction of other inanimate bodies, as well as eggs and apples, by cold; but as that intimated promiſe makes the laſt part of the title, ſo what I have to deliver on this ſubject muſt not be expected to be other than the laſt part of this ſection. And indeed to be able to add much to that little, which is generally known about this ſubject, I ſhould either have lived in colder climates than ours, or have had, which I had not, the opportunity of making experiments, that require length of time. And therefore I ſhall only propoſe a general conſideration about this matter, and ſubjoin a few of the chief obſervations I have met with in navigators or others about it. That then, which I would premiſe in general, is only this; that whether bodies be frozen by the ingreſs of frigorifick atoms, which by their intruding in ſwarms can ſcarce avoid diſcompoſing the texture of the body; or whether it be made by the receſs of ſome matter, that did, before congelation, more ſtrongly agitate its parts; which way ſoever, I ſay, freezing is effected, it is manifeſt, that the nature of a frozen body is, at leaſt for the time, much altered; and therefore we thought fit to place it among our general articles of inquiry about cold, what the effects of it may be as to the conſervation or deſtruction of the texture of bodies. But as for the duly proſecuting this inquiry, we do, as we lately intimated, want the time and conveniency, we judge needful for ſuch a work; the matter ſeeming to require, that it be watchfully and conſiderately managed, and that both the nature of particular bodies, and the differing degrees of cold, and the differing times, wherein the condition of the expoſed body is eſtimated, be taken into conſideration. For we find, that a moderate degree of cold preſerves many bodies, and that glaciation deſtroys, or at leaſt prejudices moſt others (probably by diſcompoſing or vitiating their texture) when they come to be thawed, though whilſt the froſt is in them, it keep almoſt all bodies from diſcloſing any putrefaction.

17. THIS being the general conſideration I intended to propoſe, it remains, that I add out of credible writers, or other relaters, ſome obſervations to illuſtrate and confirm the chief particulars comprehended in it.

AND firſt, that a moderate degree of cold conduces much to the preſervation of the greateſt part of inanimate bodies, is a thing vulgarly taken notice of and acknowledged. And I do not readily remember any inſtances, that manifeſt, that any degree of cold, though more than moderate, provided it fall ſhort of freezing the bodies expoſed to it, does ſpoil them. *Regii Mutinenſes* (ſays the induſtrious *Bartholinus*,) *nivem hoc fine arctè compactam ſervant in cellis nivariis, in quibus fervente æſtate vidi carnes mactatorum animalium à putredine diu ſe conſervaſſe.* The next thing I ſhall mention to our preſent purpoſe, is a memorable paſſage in captain *James*'s voyage; which ſhews, that ſo great

Barthol. de uſu Nivis, pag. 80.

great a degree of cold, as may be ſuppoſed to have reigned in his ſhip, that was frozen up all the winter in one of the coldeſt regions of the world, was not great enough to ſpoil the meat and drink, that had laid all that time under water, becauſe it ſeems by the ſtory, that they were not actually frozen; the words of his journal are theſe: "By the ninth of *May* "we were come to, and got up our five bar- "rels of beef and pork, and had four butts of "beer, and one of cyder, which God had pre- "ſerved for us: it had lain under water all "the winter; yet we could not perceive, that "it was any thing the worſe." Which is the more remarkable, becauſe of what we ſhall note by and by, both out of other books, and even out of this, about what became of a ſtronger liquor than beer, once brought to glaciation; and it ſeems our navigator found cold, if extremely intended, ſo deſtructive a thing, that he thought fit to take notice in his journal, that even a cable having lain under the ice all the winter, was not in *June* found a jot the worſe.

Page 74.

Page 79

18. And it ſeems by a paſſage in *Simlerus*'s account of the *Alps*, that even intire bodies may be very long preſerved by ſnow, and, as far as I can gueſs by the ſtory, without glaciation. *Refert* (ſays *Bartholinus*, ſpeaking of him) *in Rhetis apud Rinwaldios, nivium è monte ruentium moles ſylvam & proceras abietes dejeciſſe; accidiſſe etiam Helvetio militiæ per Alpes iter faciente, ut 60 homines & plures eadem nivis conglobatione opprimerentur. Hoc igitur nivium tumulo ſepulti, ad tempus æſtatis deliteſcunt, quo ſolutâ nonnihil nive deciduâ, corpora mortua inviolata patent, ſi ab amicis, vel tranſeuntibus quærantur. Vidimus ipſi triſte hoc ſpectaculum*, &c.

Bartho. de figura nivis pag. 79

19. Secondly, I could alledge many inſtances to ſhew, that many, if not moſt inanimate bodies, (I ſay inanimate, becauſe of the gangrenes and ſphacelations that often rob living men of frozen toes, noſes, and ſometimes other parts) if they be actually frozen, will not diſcloſe any putrifaction, whilſt they continue in that ſtate. Nor is this much to be wondered at, ſince whether he will ſuppoſe, that in glaciation the moiſt and fluid parts are wedged in by intruding ſwarms of frigorifick atoms, or that thoſe reſtleſs praticles, that were wont to keep the body fluid or ſoft, are called forth of it, be the cauſe of glaciation; which ſoever of theſe two ways we pitch upon, we muſt in frozen bodies conceive an unwonted reſt to be produced of thoſe moveable particles, whoſe internal commotions, and diſorderly coalitions and avolations, are either the cauſes or the neceſſary concomitants of corruption.

20. On this occaſion I remember, that meeting with a knowing man, whoſe affairs ſtopped him during the winter upon the coaſts of *Sweden* and *Denmark*, being deſirous to learn of him, how long they could in thoſe colder climates preſerve in winter dead bodies unburied, and yet uncorrupted, he told me, he had opportunity to obſerve, that though the froſt laſted, as it uſually did in that ſeaſon, three or four months together, or longer, the bodies might without any embalming, or other artificial way of preſervation, be kept untainted by the bare coldneſs of the air. Of bodies laſting long unputrified in ice, navigators and others have afforded us ſeveral inſtances; but we will mention two, becauſe they contain ſomething more remarkable than the reſt. The one is thus delivered by *Bartholinus*: *Notandum, corpora occiſorum hyeme eodem poſitu, eademque figurâ permanere rigidâ; quâ ante eadem deprehenſa ſunt. Viſum id extra urbem noſtram, quum* 11 Feb. 1659. *oppugnantes hoſtes repellerentur, magnaque ſtrage occumberent: alii enim rigidi iratum vultum oſtendebant, alii oculos elatos, alii ore diducto ringentes, alii brachiis extenſis gladium minari, alii alio ſitu proſtrati jacebant. Imo ex mari gelato, primo vere reſoluto, eques equo ſuo inſidens integer emerſit, neſcio quid manibus tenens.* The other inſtance is afforded us by captain *James*'s Journal, and is by him thus delivered: "In the evening "(of the 18th of *May*) the maſter of our ſhip, "after burial returned aboard ſhip, and look- "ing about her, diſcovered ſome part of our "gunner under the gun-room ports. This "man we had committed to ſea at a good "diſtance from the ſhip; and in deep water "near ſix months before. The 19th in the "morning I ſent men to dig him out, he was "faſt in the ice, his head downwards, and "his heel upwards, for he had but one leg; "and the plaiſter was as yet at his wound: "in the afternoon they digged him clear out, "after all which time he was as free from "noiſomeneſs, as when we firſt committed him "to ſea. This alteration had the ice and "water and time only wrought on him; that "his fleſh would ſlip up and down upon his "bones like a glove on a man's hand." But there is one pertinent particular more, which, if it be ſtrictly true, is ſo very remarkable, that I cannot on this occaſion forbear to annex it; which is, That according to the relation of the merchants of *Copenhagen*, that returned thither from *Spitzberg*, a place in *Greenland*, the extreme cold will there ſuffer nothing to putrify and corrupt, inſomuch that buried bodies are preſerved thirty years intire and inviolated by any rottenneſs.

Barthol. *de uſu nivis* p. 83.

Capt. James's travels, p. 76.

Barthol. *de uſu nivis, c.* 12.

21. Thirdly, though whilſt bodies continue frozen, the cold (as may be ſuppoſed) by arreſting the inſenſible particles, from whoſe tumultuary motions, and diſorderly avolations corruption is wont to proceed, may keep the ill operations of cold upon the violated textures of bodies from appearing; yet when once that impediment is removed, divers bodies make haſte to diſcover, that their texture was diſcompoſed, if not quite vitiated by the exceſſive cold. I might alledge on this occaſion, that I have ſhewn divers ingenious men by an experiment that I have taught in another * treatiſe, that the change produced in the textures of ſome bodies by glaciation, may be made manifeſt even to the ſight. For by freezing an ox's eye, the cryſtalline humour, which in its natural ſtate is tranſparent enough, to deſerve its name of cryſtalline, though not fluid enough to deſerve the name of humour, loſt with its former texture all its diaphaneity, and

* *Of the uſefulneſs of Experimental Philoſophy.*

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being cut in two with a ſharp knife, appeared quite throughout very white. But for confirmation of this I ſhall rather add, that I remember, that the perſon formerly mentioned, that had made trial of the two cheeſes, confeſſed to me, That, though that, which had been thawed in cold water, was very much the leſs ſpoiled, yet they were both of them manifeſtly impaired (and the other of them was ſo in its very conſiſtence) by the froſt, though the bulk of the cheeſes was very conſiderable, and though they vere both of them, of a more than ordinarily good and durable ſort.

22. THE next thing I ſhall alledge to this purpoſe, is the obſervation of the *Hollanders*, even by ſuch a degree of cold as they met with in *Nova Zembla*, before the middle of *October*, at which time their ſtrong beer, by being partly frozen, had its texture ſo vitiated, that the reunion of its unfrozen to its thawed parts could not reſtore any thing near ſuch a ſpirituous liquor, as it was before. "We were Purch. *Lib.* 3. *cap.* 5. *ſect.* 2. *pag.* 493. "forced (ſays *Gerat de Veer*, that wrote the "ſtory) to melt the beer, for there was ſcarce "any unfrozen beer in the barrel, but in that "thick yeaſt, that was unfrozen, lay the "ſtrength of the beer, ſo that it was too "ſtrong to drink alone; and that which was "frozen taſted like water, and being melted, "we mixed one with the other, and ſo drank "it, but it had neither ſtrength nor taſte." And in the next month's journal he tells us, that their beſt beer was for the moſt part wholly without ſtrength, ſo that it had no ſavour at all. But a more remarkable inſtance to our preſent purpoſe is afforded us by our countryman captain *James*, becauſe it manifeſts the cold to have the ſame effect upon a much ſtronger and more ſpirituous liquor. "I *Pag.* 73. "ever doubted (ſays he in his journal) that we "ſhould be weakeſt in ſpring, and therefore "had I reſerved a tun of *Alicant* wine unto "this time. Of this, by putting ſeven parts "of water to one of wine, we made ſome "weak beverage, which (by reaſon that the "wine by being frozen, had loſt his virtue) "was little better than water."

23. AND I remember, that a learned man, whom I aſked ſome queſtions concerning this matter, told me, that in a northern country, leſs cold than *Muſcovy*, he had obſerved, that beef having been very long frozen, when it came afterwards to be eaten, was almoſt inſipid; and being boiled, afforded a broth little better than common water.

24. IF I had not wanted opportunity, I ſhould here ſubjoin an account of ſome trials, for which I made proviſion, as thinking them not abſolutely unworthy the making, though extravagant enough not to be likely to ſucceed. For I had a mind to try, not only whether ſome plants, and other medicinal things, whoſe ſpecifick virtues I was acquainted with, would loſe their peculiar qualities by being throughly congealed, and (ſeveral ways) thawed; and whether thawed hartſhorn, of which the quantity of ſalt and ſaline ſpirit of ſuch a determinate ſtrength ſhould beforehand be tried by diſtillation, would, after having been long congealed, yield by the ſame way of diſtillation the ſame quantity of thoſe actual ſubſtances, as if the hartſhorn had not been frozen at all. But I had alſo thoughts to try, whether the electrical faculty of amber, (both the natural, and that factitious imitation of it I elſewhere teach) and whether the attractive or directive virtue of loadſtones, eſpecially very weak ones, would be either impaired, or any ways altered by being very long expoſed to the intenſeſt degrees of cold within my power of producing. But to have named ſuch extravagancies, is that, which I think enough, and others I fear may think too much.

25. YET ſome few things I ſhall ſubjoin on this occaſion, becauſe it will add ſomewhat not impertinent to the deſign of this treatiſe (which is to deliver the phænomena of cold) as well as countenance what I have been propoſing; and thoſe things are, that I can by very credible teſtimony make it appear, that an intenſe cold may have a greater operation upon the texture even of ſolid and durable bodies, than we in this temperate climate are commonly aware of. I ſhall not urge, that even here in *England* it is generally believed, that men's bones are more apt to break upon falls in froſty, than in other weather, becauſe that may poſſibly be imputed to the hardneſs of the frozen ground. Nor, that I remember, when I was wont to make uſe of ſtone-bows, I found it a common obſervation, that in froſty weather the laths, though of ſteel, would, by the cold, be made ſo brittle, that unleſs extraordinary care were had of them, or ſome expedients were uſed about them, they would be apt to break. Nor yet, that an ingenious overſeer of great buildings has informed me, that thoſe that deal in timber and other wood, find it much more eaſy to be cleft in hard froſts, than in ordinary weather. Theſe and the like inſtances I do, as I was intimating, forbear to urge, becauſe theſe effects of cold are much inferiour to thoſe that have been met with in more intemperate regions.

26. AND to begin with its operation upon what we were laſt treating of, wood. Of *Charleton*-iſland, captain *James* has this paſſage about the timber, they employed upon their works: 'The boys (ſay he) with cuttle- *Pag.* 67. 'axes muſt cut boughs for the carpenter; 'for every piece of timber, that he did work, 'muſt firſt be thawed in the fire.' And a little before, he tells us, that even when they found 'a ſtanding tree, they muſt make a fire to 'it to thaw it, otherwiſe it could not be cut.'

27. AND I remember, that two ſeveral perſons, both of them ſcholars, and ſtrangers to one another, that had occaſion to travel as far as *Moſcow*, aſſured me, that they divers times obſerved in extreme froſts, that the timber-work (whether the boards or the beams) of ſome houſes, which, according to the cuſtom of that country, were made of wood, and perhaps, not well ſeaſoned, would, by the operation of the cold, be made to crack in divers places, with a noiſe, which was ſurprizing enough to them, eſpecially in the night.

28. I REMEMBER alſo, that a phyſician, who lived for ſome years in one of the coldeſt plantations of the *Weſt-Indies*, related to me, that

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that he had obſerved the bricks, he had employed about building, to be very apt to be ſpoiled by the long and vehement froſts of the winters there; where he likewiſe ſaid, that it was a uſual thing for the houſes builded of brick, to decay in fewer years by far, than here in *England*; which he ſaid was generally, and, as he thought, truly imputed to the exceſſive cold, which made the bricks apt to crumble, and moulder away. But though I dare not lay much weight on this obſervation, unleſs I knew, whether the bricks were ſufficiently burned, and free from pebbles, calcinable by the heat that burned the bricks; yet we muſt not deny, that extreme colds may be able to ſhatter or diſſolve the texture of as cloſe and ſolid bodies as bricks, eſpecially if the aqueous moiſture be not ſufficiently driven away; if we will admit, what I remember I have mentioned in another treatiſe, out of a very learned and credible author, of the power, that a freezing degree of cold has had to break even ſolid marble. And much leſs ſhall we doubt the poſſibility of what the phyſician related, if we will not reject the teſtimony of the learned *Olaus Wormius*, according to which, inſtruments made even of ſo hard a metal as braſs are not privileged from the deſtructive operations of ſome degrees of cold. For, *Ex ære facta opera* (ſays he in his curious *Muſæum*) *vi frigoris quandoque rumpuntur, quod tamen pauci credunt, id tamen expertus eſt Eratoſthenes, & noſtras Johannes Munckius in difficillimo ſuo itinere, quo per fretum Chriſtianum tranſitum in mare Auſtrale invenire moliebatur.* To which, perhaps moſt writers would, if they met with it, add this paſſage out of the Dutch-mens voyage to *Nova Zembla:* 'The 20th (of *October*) it was calm 'ſunſhiny weather, and then again we ſaw 'the ſea open, at which time we went on 'board, to fetch the reſt of our beer out of 'the ſhip, where we found ſome of the barrels frozen in pieces, and the iron hoops, that 'were upon the joſam barrels, were alſo frozen in pieces.' But though this teſtimony ſeems to prove, that extreme cold may break even iron it ſelf, and though poſſibly ſuch an affirmation might in the general not be erroneous, yet I ſhall forbear to draw that inference from this paſſage, becauſe I ſuſpect, that ſince the irons, that were broken, were hoops, and ſince it ſeems probable by the ſtory, that there were barrels not hooped with iron broken alſo by the ſame froſt; the breaking of the hoops may have been the effect, not of the violence of the cold, as acting immediately upon the iron, but of the liquor in the veſſels, which being, by the cold that froze it, turned into ice, was ſo forcibly expanded, as to burſt whatever oppoſed its dilatation, according to what we ſhall have occaſion in its due place more fully to deliver.

Lib. 1. Sect. 3. pag. 122.

An Appendix to the VIth *title.*

INQUIRING of the formerly mentioned phyſician to the Ruſſian emperor, what experience teaches about ſome of the matters treated of in this (ſixth) title, in thoſe cold climates, where the effects of freezing are more notable; he told me, that the tradition (mentioned above, touching the ſafeſt way of thawing) is *in Muſcovy* generally received; and that it is uſual for men, that have their cheeks and noſes frozen, to rub them well with ſnow, and eſcape unharmed; whereas if they go immediately into their ſtoves, they often loſe the tops of their noſes, and introduce into their cheeks a kind of paralytick diſtemper, or benumbedneſs, that they cannot get rid of in many months.

AND having alſo inquired of the ſame ingenious perſon, whether wine frozen, and then permitted to thaw, till the unfrozen liquor had quite reſolved the ice, was not thereby ſpoiled by having its texture vitiated; he anſwered, that in very ſtrong claret-wine he found the colour ſcarce at all deſtroyed, nor the liquor otherwiſe much impaired; but that in weaker claret-wine the colour was ſpoiled, and the liquor was otherwiſe much the worſe. But note, that in the French wine there remained a third part or more unfrozen, ſo that it ſeems not to have been expoſed to near ſo extreme a cold, as that of the Hollanders, or of captain *James*; and that phyſician likewiſe told me, that of ſome very ſtrong beer, that he had in great part frozen, the ice had ſome taſte of the hops, but was diſpirited like phlegm.

HAVING inquired how long dead bodies would keep, he told me, that if they were thoroughly frozen, they would be preſerved incorrupted till the thaw, though that perhaps might not happen within four or five months after the death of the man. He added, that he had the veniſon of elks ſent him unſalted, and yet untainted, out of *Siberia*, (which is ſome hundreds of leagues diſtant from *Moſcow*;) and that beef and other fleſh well frozen, would keep unputrified for a very long time. And when I aſked, whether the freezing did not impair it, he anſwered, that with long keeping it congealed, it will grow very dry and be impaired in taſte, and will not make ſo good broth as meat that was never frozen. And he further told me, that in caſe frozen meat were leiſurely thawed, it would be far the leſs impaired, and might be well roaſted; but if before it was thawed, it were laid down to the fire, it would not ever be well roaſted, and would eat very ſcurvily: and though a ſhoulder of mutton, for inſtance, were kept very many hours turning before the fire, yet it would continue raw in the middle.

HAVING inquired about the rubbing bodies with ſnow to unfreeze them, he told me (agreeable to what I noted him to have ſaid above) that he had ſeen ſeveral perſons, that had been frozen, and that when a man is told, that he is frozen, and having aſked whereabouts (for the party himſelf uſually knows it not) is informed, that it is in this, or that place, which is commonly the noſe or the upper part of the cheek, or perhaps the tip of the ear; he uſually rubs the part very well with ſnow, and lets it thaw by degrees; elſe, if without that preparation he ſhould go immediately into the ſtove, he would be in danger to loſe his noſe, or other frozen part. The doctor added, that they uſe to rub the frozen meat and fiſh with ſnow, and

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and that he once examined a man, who in his youth had been frozen all over, and informed the doctor, that having had occaſion in a journey to quit his ſled for a while, and do ſome exerciſe, that had almoſt made him ſweat, being careleſs of himſelf, when he returned to the ſled again, he was frozen all over, and had ſo died, had not the company by accident taken notice of him, and by rubbing him over with ſnow, and by the uſe of the like means recovered him again; but he told the doctor, that by this whole accident he was put to no pain, ſave that when he came to himſelf again, he felt ſuch a pricking all his body over, as men are wont to find in an arm or leg benumbed, by having been long leaned upon.

WHEN I aſked, whether the ſharpneſs of the cold did not work upon the ſtones, he anſwered, that as to flints he could not tell; but as to other ſtones, and ſuch as are oftentimes uſed for building, the violence of the cold made them frequently moulder into duſt. And to ſatisfy my curioſity about the effect of cold upon wood, he told me, that he had very often in the night, eſpecially when their keen froſts were unaccompanied with ſnow, heard the trees cleave and crack with very great and ſometimes frightful noiſes; and that the outſide of the fir-trees, that were laid upon one another in their buildings, and was expoſed to the air, would do the like; and that he had often ſeen the gaping clefts ſometimes wide enough to put in his fingers, which would remain in the trees, and in the fir-wood, till the thaw, after which they would pretty well cloſe of themſelves.

TITLE VII.

Experiments touching the expanſion of water, and aqueous liquors, by freezing.

1. THAT water and other liquors are condenſed by cold, and ſo much the more condenſed, by how much the greater the degree of cold is that condenſes them, has been for many ages generally taught by the ſchools, and taken for granted among men, till of late ſome more ſpeculative than the reſt, have called it in queſtion upon the account of the levity of ice; ſince which, I have met with two modern writers, that have incidentally endeavoured to prove, that ice is water, not condenſed, but rarified by the intumeſcence of water expoſed to freezing in veſſels fitly ſhaped.

THESE attempts of theſe learned men putting me in mind of what I had tried to this purpoſe, when I was ſcarce more than a boy, invited me to conſider, that by the uſual ways of glaciation, ſuch as theſe ingenious men employed, the experiment is wont to meet with a diſaſter, by the breaking of the glaſſes, which not only makes the event liable to ſome objections of theirs, that befriend the common opinion, but (which is more conſiderable) hinders them from judging what this expanſion of water, that is made by freezing, may amount to. Wherefore we will now ſet down what we have done to aſcertain (and yet limit) the experiment, as alſo to advance it further.

2. WHEREAS then theſe two learned men, we have been mentioning, do ſo expoſe the water to freeze, that it is turned into ice at the top as ſoon as elſewhere; the inconveniences of which way, we have already noted; we, by freezing the water, as we have formerly taught from the bottom upwards, can eaſily preſerve our glaſſes intire, and yet turn the whole contained water into ice: ſo that if according to this way you ſo place a bolt-head or a glaſs-egg, in whoſe cavity the water aſcends to the height of an inch, or thereabouts, within the ſtem or ſhank, in a mixture of ice, or ſnow and ſalt, as that the water is firſt turned into ice at the bottom and ſides, and not till the very laſt at the top, you ſhall manifeſtly ſee, that the ice will reach a good way higher in the neck, than the fluid water did, and that upon a gentle thaw of the ice, the water it returns to, will reſt at the ſame height in the ſtem, to which it reached, before it was expoſed to be frozen.

3. WE have likewiſe uſed other ways unſpoken of by the lately mentioned writers, to evince, that water is expanded by being frozen; as firſt, that we took a ſtrong earthen veſſel of a cylindrical form, and filling it with water to a certain height, we expoſed it unſtopped, both to the open air in froſty nights, and to the operation of ſnow and ſalt, and found that the ice did manifeſtly reach higher than the water did, before it was congealed.

BESIDES, if a hollow pipe or cylinder, made of ſome compact matter, be ſtopped at one end with wax, or ſome things elſe, which it may be more eaſy to drive out, than to burſt the cylinder; and if at the other end it be filled with water, and that orifice alſo be ſtopped after the ſame manner; this pipe, ſuſpended in a ſufficiently cold air will have the included water frozen, and by that change, if the experiment have been rightly made, the water will upon congelation take up ſo much more room than it did before, that the above-mentioned ſtopples, or at leaſt one of them, will be thruſt out, and there will be produced a rod of ice a good deal longer than the pipe, at each of whoſe ends (or at leaſt at one of them) a cylindrical piece of ice of a pretty length may be broken off, without meddling with the pipe, or the ice that fills it.

DIVERS other ways of proving the ſame truth might be here alledged, but that, though theſe were not, as they are, ſufficient, the matter would yet be abundantly confirmed by divers of the experiments, that will here and there come in more opportunely in the following part of this treatiſe.

4. BUT here it will not be altogether impertinent or unſeaſonable to take notice, that not only thoſe ſchool-philoſophers, who have conſidered the breaking of well-ſtopt glaſſes in froſty weather, (an accident but too frequent in apothecaries ſhops, and laboratories) but divers modern virtuoſi, are wont to aſcribe the phænomenon to this, that the cold of the external air, contracting the air and liquor within, the ambient air muſt break the ſides of the glaſs to fill that ſpace, which being deſerted

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ſerted upon the condenſation of the included air, the liquor would otherwiſe leave a vacuum abhorred by nature; and even thoſe few moderns, that are loth to aſcribe this phænomenon to nature's abhorrency of a vacuum, either not being acquainted with the weight of the air, know not what probable account to give of it; or if they acknowledge that weight, are wont to aſcribe it to that, and to the great contraction of the internal air, made by the cold of the external.

5. But as for the Peripateticks, the abovementioned experiments ſufficiently evince, that in many caſes, it is not the ſhrinking, but the expanſion of the liquors contained in the ſtopt veſſels, that occaſions their burſting; and therefore in theſe caſes, we need not, nor cannot fly to I know not what *fuga vacui* for an account of the phænomenon. And whereas it may be objected, that even glaſſes not half full of diſtilled waters, if they be exactly ſtopt, are often broken in apothecaries ſhops: I anſwer, That neither in this caſe do I ſee any need of having any recourſe, either to the *fuga vacui*, or to the weight of external air; for even here the expanſion of the freezing liquor may ſerve the turn; for in ſuch inartificial glaciations the liquor begins to freeze at the top, and the ice there generated, faſtening it ſelf (as on other occaſions we declare) very ſtrongly to the ſides of the glaſſes, contiguous to its edge, as the liquor freezes deeper and deeper, this cruſt of ice increaſes in thickneſs and ſtrength, ſo that the water is included, as in a veſſel hermetically ſealed betwixt this ice at the upper part, and the ſides and bottom of the glaſs every where elſe; and conſequently, the remaining water being uncapable of congelation without expanſion, when the ice is grown ſtrong enough at the top, to make it eaſier for the expanſive endeavour of the freezing water to crack the ſides or bottom of the glaſs, than to force up that thick cake of ice, the veſſel will be broken, how much ſoever there be of it empty above the ſurface of the ice. And this conjecture may be confirmed by theſe two particulars: the one, that when water is frozen in a broad veſſel, which is too ſtrong to be broken or ſtretched by the froſt, the ſurface of the ice contiguous to the air will be convex or protuberant; becauſe, that though the glaciation began at the top, the thickneſs and compactneſs of the veſſel makes it eaſier for the expanſive endeavour to thruſt up that cake of ice in thoſe parts of it, that are the remoter from the ſides, whereunto they are ſtrongly faſtened, than to break ſo ſolid a veſſel.

6. The other particular is afforded us by that experiment of ours, (mentioned in the fifth title foregoing) wherein if a veſſel half full of water be made to freeze, not firſt at the top, but at the bottom, that liquor may be turned into ice without danger to the glaſs. But we will now add an experiment, on whoſe occaſion we have ſet down thoſe conſiderations. For being inclined to think, that the ſpring of the air, ſhut up in a veſſel ſtopped, will preſerve it expanded, or at leaſt keep it from conſiderably ſhrinking, notwithſtanding a very great degree of cold, in caſe the veſſel be ſtrong and cloſe enough to fence it from the preſſure of the external air, we conjectured; that the bare weight of the outward air, added to the refrigeration of the included air, would not be ſufficient to break much weaker glaſſes, than thoſe we have been ſpeaking of. And therefore partly to ſatisfy ſome ingenious men, that this conjecture made me diſſent from, and partly to ſhew the Peripateticks, and thoſe that adhere to them in the queſtion under conſideration, that either the cold alone cannot always, as they teach us, contract the air, or that, if it do, the breaking of well-ſtopped glaſſes in froſty weather is much fitter to evince, that there may be a vacuum, than that there can be none, we made the following experiment.

7. We took three glaſs-bubbles of differing ſhapes and ſizes, which we cauſed to be blown with a lamp, that, to make the experiment very favourable for our adverſaries, we might have them much thinner, and conſequently, weaker than thoſe glaſſes, that are wont to be made uſe of to keep liquors in, and which, notwithſtanding, are wont to be broken, though they be not full, by the froſt.

These bubbles, when the air was at a convenient temper within, were (as eaſily they might be) nimbly ſealed up with care, to avoid the heating of the air in them; and being afterwards expoſed ſometimes to the air it ſelf in very froſty weather, and ſometimes to that greater cold, which is produced by the placing them in a mixture of ſnow and ſalt, we could not nevertheleſs find, that any one of the three was at all broken or cracked; ſo that in caſe the included air were condenſed into a leſſer room, the ſpace it deſerted may be concluded empty, or elſe it will hardly appear, what neceſſity there can be, that nature ſhould break, as the Peripateticks pretend, very much ſtronger glaſſes in apothecaries ſhops, to prevent a vacuum.

8. Having ſhewn, that water it ſelf acquires a conſiderable expanſion by cold, we will next ſhew, that aqueous bodies, or thoſe that abound with wateriſh parts, do divers, if not all of them, the like.

We took eggs, and expoſing them to a ſufficient degree of cold, we obſerved, that when the contained liquors were turned into ice, they burſt the ſhells aſunder; ſo that divers gaping cracks were to be ſeen in them, as long as they continued frozen.

9. Milk, urine, Rheniſh-wine, and good ſpirit of wine, being ſet to freeze in diſtinct glaſs eggs, neither of the three former liquors was obſerved to ſubſide before it began to riſe. The event in ſum was, that the urine was much longer, than either of the two other liquors, before it began to ſwell, but roſe to a far greater height, than they, afterwards. The wine did not leave the mark above an inch beneath. The milk aſcended about two inches, and the urine by gueſs ſix or ſeven.

10. A Strong ſolution of *Dantzick* vitriol being put into a cylindrical pipe, ſealed at one end ſo, that the liquor filled the pipe to the height of about ſix or eight inches, being frozen with ſnow and ſalt, the congealed liquor grew very opacous, and looked as if it had

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had been turned or ſhot into vitriol, ſave a little, that remained fluid, and tranſparent near the bottom. And this ice, as appeared, roſe conſiderably higher than the liquor did before congelation.

IT were perhaps worth trying, whether or no even ſeveral bodies of a ſtable conſiſtence, and durable texture, might not be found to receive ſome, though leſs manifeſt dilatation by exceſſive cold. And methinks thoſe, who attribute glaciation to the plentiful ingreſs of frigorifick atoms into bodies, ſhould by their hypotheſis have been invited to make ſome trials of this kind, ſince we ſee, that the inviſible moiſture of the air againſt rainy weather does ſeem manifeſtly enough to alter the dimenſions of doors, window-ſhutters, and other ſuch works made of wood not well ſeaſoned. And even without ſuppoſing the truth of the Epicurean hypotheſis, if we conſider, that in bread, though we are ſure, that much more water was added to the meal, or flower, than was exhaled in the oven, yet there appears not the leaſt drop of water diſtinct in the concrete, and that harts-horn, ſponges, and many other bodies, that ſeem very dry, will afford by diſtillation good ſtore of phlegm or water, and more than can probably be aſcribed to any tranſmuting operation of the fire: if, I ſay, we conſider theſe and the like things, it may ſeem worth while to try (which I want the conveniency to do) by accurate meaſures, whether the inviſible and interſperſed water, its comminution notwithſtanding, will not upon freezing ſwell the body, that harbours it. And I would the more gladly have been ſatisfied in this, becauſe I hoped it might help me to unriddle a ſtrange phænomenon, afforded us by the narrative of the Dutchmen's voyage to *Nova Zembla*, wherein they relate, 'that the cold was ſo great, 'that their clock was frozen, and would not 'go, though they hung more weight upon it 'than before:' ſo that they were fain to meaſure their time by hour-glaſſes. For though this odd effect might be ſuſpected to proceed from ſome litte icicles ſticking to ſome of the wheels, or the line, in regard they not far off tell us, that the ſteams of their bodies, and other things within their cloſe houſe*, did ſo faſten themſelves to the walls, to the roof, and even to their cabins, as to line them with ice, of no leſs than two fingers thick; yet beſides that it cannot be probably ſuppoſed, that they, who had ſo great need of their clock, during the tedious abſence of the ſun for many weeks together, ſhould not all the winter long be aware of this; beſides this, I ſay, I find, that in captain *James*'s wintering at *Charleton*, his clock and watch were ſo frozen too, 'that they could not go, notwithſtanding
Page 64 'they were ſtill kept by the fire-ſide in a 'cheſt, wrapt in cloths.' So that in caſe it appear, that, according to what we formerly noted out of *Wormius*, the froſt can get into metals, it can alſo diſtend them, and other ſtable bodies; we might conceive, that the ſtopping of the clocks might proceed from the ſtiffneſs, or the ſwelling of the line, to which the weight was faſtned, or a ſwelling even of ſome of the wheels, or other metalline parts of the clock, that may ſpoil the neceſſary congruity between the teeth, *&c.* as I have tried, that ſome parts of an iron inſtrument, I cauſed to be made, would by no means fit one within another, when expanded by much heat, (and though cold be the cauſe of the expanſion, the effect may be the ſame) though at other times they would. And if we knew, whether ſprings loſe any thing of their elaſticity by the violence of the cold, we might thence alſo be aſſiſted to gueſs, whether the froſt's operation upon the ſpring of captain *James*'s watch (for he mentions that, as diſtinct from his clock) might contribute any thing to the forcing it to ſtand ſtill. But theſe are bare conjectures, from which I will therefore paſs on to the following ſection.

TITLE VIII.

Experiments touching the contraction of liquors by cold.

1. BUT notwithſtanding all the former experiments, we muſt not conclude univerſally, that all liquors are diſpoſed to be expanded by cold, neither by a moderate degree, nor even by ſo intenſe a degree of it as ſuffices to freeze or congeal the liquors expoſed to it. This we have tried, not only in ſpirit of wine, aqua fortis, oil of turpentine, and divers other liquors, that we could not bring to freeze, but alſo in oil congealed by the vehemence of cold; ſo that as to the change of dimenſions produced in liquors by cold, there muſt be a great difference allowed betwixt water and aqueous liquors on the one ſide, and oil and divers other liquors, that are ſome of them of an oleaginous, and ſome of a very ſpirituous, or very highly corroſive nature, on the other ſide. Nor have we yet made trials enough to reduce this matter to a certainty. For though we could not bring ſome ſtrong ſaline ſpirits, nor the moſt of chymical oils to freeze; yet in ſome our attempts ſucceeded not ill. But I remember not, in any liquor we could by cold produce any ſenſible expanſion, but rather a manifeſt condenſation, unleſs we could bring it actually to freeze.

2. THE trials we made of the efficacy of cold to condenſe liquors, were many; but it may, for the preſent, ſuffice to ſet down two or three differing ones, that occur to us in our collections.

To the entry of the experiment lately recited, of the expanſion of milk, urine, and the Rheniſh wine, there are ſubjoined theſe words:

[BUT the egg, that held the ſpirit of wine, though it were much ſmaller than we uſually employ, and fitted with a proportionably ſlender ſtem, and though it were kept divers hours partly in ice and ſalt, and partly in ſnow and ſalt, yet it froze not at all, but ſubſided by degrees below the firſt mark to the quantity of $\frac{1}{4}$ of an inch in the ſtem; and though it afterwards

* It froze ſo ſore within the houſe, that the walls and the roof thereof were frozen two fingers thick with ice, and alſo in our cabins, where we lay all thoſe three days, while we could not go out. *Gerat de Veer* in his third Voyage.

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afterwards ſeemed to riſe a little, yet it never ſwelled up again to the ſaid firſt mark.]

3. We took a round bolt-head of about in diameter, and poured in mercury till it reached a pretty way into the neck, which was purpoſely drawn more ſlender than ordinary; and having, without approaching it to the fire, freed it from ſome of the larger bubbles of air, that appeared at the ſides, we put it into a mixture of ice and ſalt, where the cold ſo wrought upon it, that watching it attentively, we could diſcern not only its having moved, but its motion downwards, which it continued (though not viſibly in the progreſs, as at the firſt) till it was ſubſided in the neck two inches or better, which was far more than could be attributed to the contraction of any ſenſible aërial particles, though they had loſt not only the 30th part of their dimenſions, as we have ſometimes obſerved of the air, but had been contracted to a point; and we obſerved too, that the quick-ſilver once thus infrigidated, though not frozen, retained ſome of the acquired cold, for many hours after, as appeared by its keeping below the mark of its firſt height, though we had kept it all night in a warm room.]

[4. We took a ſmall egg with a proportionably ſlender ſtem, into which we poured common oil, till it roſe a pretty way (but not much) above the oval part of the glaſs; then having put a mark upon the ſtation of the liquor, we placed the veſſel in ſnow and ſalt, and obſerved it not to ſwell as other liquors, but to ſubſide, with cold; till being quite frozen or congealed, it appeared to be ſhrunk about an inch or more beneath the mark; then being thawed, it ſwelled again to the mark.]

5. The experiment was repeated the ſecond time, with not much worſe ſucceſs; but we found, that if the glaſs were removed out of the ſnow into ſome place near the fire, the hot air would not only thaw it, but ſo rarify it, as to make it aſcend above the mark. A third time we ſealed up the ſame oil in the ſame glaſs, and repeated the experiment, with like ſucceſs to that we had the ſecond time; and that the frozen oil was really condenſed, we found, becauſe it would ſink in oil of the ſame kind, cold, but unfrozen; and this, notwithſtanding divers bubbles, which we obſerved uſually to be made about each lump of congealed oil, that we caſt in, upon its beginning to ſink in the fluid oil. This we tried, both with oil well congealed (or if another word pleaſe better, incraſſated or curled) by ſnow and ſalt, and with oil leſs congealed, frozen by the bare cold of the ambient air; but this latter ſeemed, to ſight, to ſink more ſlowly than the other, and being leſs congealed and ponderous, yet would not lumps of the maſs of oil ſink or continue immerſed. I ſay, not in common water, but in ſack or claret wine; and if thruſt down into either of theſe liquors, they nimbly enough emerged.

6. Whether or no chymical oils, though, like expreſſed oils, they ſhrink with a moderate degree of cold, would by congelation be, like them, contracted, or like aqueous liquors expanded, we could not ſatisfy ourſelves by experiment, becauſe we were unable to advance cold to a degree capable of bringing ſuch oils to congelation; only we had thoughts to make a trial with oil of aniſeeds, diſtilled with water in a limbeck, in regard, that though it be a very ſubtile liquor, and, as chymiſts call it, an *eſſential* oil; and though in the ſummer-time, and at ſome other ſeaſons (if the weather be warm) it will remain fluid; yet in the winter, when the air is cold, it will, if it be well drawn, and genuine, eaſily enough loſe its fluidity; and therefore we thought it might do well to pour ſome of it, in moderate weather, into a conveniently ſhaped glaſs, and then to freeze it externally by the application of ice and ſalt, that we might obſerve, whether upon congelation it would ſhrink or be expanded. And accordingly, though we were not provided with any quantity of this oil, yet in weather, that was not ſharp, we did, by the help of ſome ice, which we procured, when the ſeaſon made it a rarity, ſurround a glaſs pipe filled with fluid oil of aniſeeds, and found, though the pipe were but ſhort, yet the incloſed ſubſtance, when it had loſt its fluidity, had conſiderably loſt of the height, which it reached to before.

7. And becauſe the empyreumatical oils, that are driven out of the retorts by ſomewhat violent fires, ſeemed to be of a nature differing enough from thoſe eſſential oils (as artiſts call them) which are drawn in limbecks by the help of water as well as fire; and becauſe we obſerved, that ſome of the firmer oils may be uſed in phyſick, in much larger doſes than it is thought ſafe to give the latter in: conjecturing from hence, that probably empyreumatical oils may be leſs hot, and ſo leſs indiſpoſed to congelation, we thought fit to make trial (nobody elſe in probability having done it) whether the cold in our climate could be brought to freeze theſe oils, and whether it would expand or condenſe them. Wherefore expoſing, in conveniently ſhaped veſſels, ſome good oil of guaiacum, that was diaphanous enough, though very highly coloured, to the greateſt cold we could produce, we attempted, but in vain, to deprive it of its fluidity; all that we were able to effect, being to make it very manifeſtly ſhrink.

TITLE IX.

Experiments in conſort, touching the bubbles, from which the levity of ice is ſuppoſed to proceed.

1. SINCE the firſt thing, that made the moderns ſuſpect, that water is expanded by freezing, is the floating of ice upon water; it will not be amiſs, for confirmation of that argument, to take ſome notice of the levity of ice in reſpect of water. This is beſt obſerved in great quantities of ice; for whereas in ſmall fragments or plates, the ice, though it ſink not to the bottom of the water, will oftentimes ſink ſo low in it, as ſcarce to leave any part evidently extant above the ſurface of the water, in vaſt quantities of ice, that extancy is ſometimes ſo conſpicuous, that navigators in their voyages to *Iceland*, *Greenland*, and other frozen regions,

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regions, complain of meeting with lumps, or rather floating rocks of ice, as high as their main-masts. And if we should meet with cases, wherein we might safely suppose the ice to be as solid as entire pieces of ice are wont to be with us, and not to be made up of icy fragments cemented together, with the interception of considerable cavities filled with air, it would not be difficult for any, that understands hydrostaticks, to give a pretty near guess at the height of the extant part, by the help of what we lately observed of the measures of water's expansion, and by the knowledge of the immersed part; which supposing, that the ice were of a prismatical figure, and floated in an erected posture, would, in fresh water, amount to about eight or nine times the length of the part of the prism superiour to the surface of the water.

2. BUT because perhaps the great disparity in the degrees of cold, whereby water is in this, and in those gelid climates turned into ice, may breed a difference in the expansion of the frozen water; and because some other circumstances may be needful to be taken into consideration, about the height of floating ice above water, and these will be more properly taken notice of under the following title; I shall only upon this head (*of the levity of ice*) subjoin the ensuing transcript of one of our notes concerning that subject.

[WE found, that pieces of ice, clear and free, for aught the eye could take notice of, from bubbles, would not be made to sink in spirit of wine once distilled from brandy, and it floated likewise in strong spirit of wine drawn from quick-lime; but if the spirit of wine were well warmed, such ice, as I mentioned, would sink in it, though as it grew cold, the same ice would slowly ascend, and sometimes remain for a while, as if it were suspended without sensibly rising or falling. But all this while the ice, thawed apace in the water, whereinto it was dissolved, did manifestly seem to run down like a stream through the lighter body of the spirit of wine, the diversity of the refractions making this easy to be taken notice of; yet common water, though heated as hot as I could endure to hold the glass in my hand, would not let the fragments of the same parcel of ice sink into it; but in oil of turpentine, and in thrice rectified spirit of wine, the ice would sink like a stone.]

3. THAT the levity of ice, in respect of water, proceeds from the bubbles, that are produced in it, and make the water, when congealed, take up more room than when fluid, has scarce been doubted by any, that has considered the texture of ice, as well as taken notice of its levity. But if this be the true and only reason, we may conjecture, that there must be great store of bubbles in ice, extremely minute, and undiscerned by the naked eye. For though in very many parcels of ice, the bubbles are as well conspicuous as numerous, insomuch that they render the ice whitish and opacous, yet we have observed, that other pieces would swim, which yet were of an almost crystalline clearness. And therefore we thought fit to look upon some clear pieces of ice in a microscope, and we shall subjoin the event, because that when we beheld some of this ice in one of our microscopes, which has been counted by several of the curious, as a good a magnifier, as perhaps any is in the world, we could not discover such store of bubbles, as it seemed there should appear upon the supposition, that the adequate cause of the levity and expansion of frozen water is but the interspersion of such bubbles.

THE observations I have been mentioning, I find thus set down among my notes.

[A piece of ice, that to the eye looked clear like crystal, being put into the great microscope, appeared even there free from bubbles; and yet the same piece of ice being presently removed, and cast into common water, would swim at the top, and, if it were forcibly duck'd, would swiftly enough emerge.

ANOTHER piece of ice, that to the naked eye was not so clear as the former, appeared in the same microscope to have store of bubbles, some of them appearing there no bigger than a small pin's head, and some of them being yet lesser, and scarcely visible in the microscope itself.]

AND here, because it seems a considerable doubt, and well worth the examining, whether or no water, when frozen into ice, grows heavier or lighter, not in reference to such water as it was generated of, (since it is evident, that upon that it will float) but more absolutely speaking, we judged it not amiss to examine this matter by an experiment; but we could not discover any difference between the weight of the same parcel of water fluid and frozen, as will appear by the ninth paragraph of the experiment to be a little beneath recited.

BUT since that, whether or no we allow any other cause, together with the bubbles, to the levity of ice, it seems a thing not to be doubted, that its expansion and lightness is mainly, if not only, due to the interspersion of bubbles, the generation of them seems to be one of the considerablest phænomena of cold, and the investigating by what cause those cavities are produced, and in case they be perfectly full, what substance it is that fills them, is none of the meanest enquiries, that should exercise the industry of a searcher into the nature of cold.

4. Mr. *Hobbes*, and some others seem to think, that the expansion of water by congelation, is caused by the intrusion of air, which constitutes those numerous bubbles wont to be observed in ice; we might here demand, why in case, that upon freezing there must be a considerable accession of air from without, when oil is frozen, it is, notwithstanding the ingress of this air, not expanded, but condensed: but because these conjecturers do not allow glass to be pervious to common air, we shall at present press them with this experiment, which we have divers times made.

WE took a glass-egg with a long stem, and filling it almost with water, we sealed it hermetically up, to exclude the pretence that some adventitious air might get in, and insinuate

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nuate itſelf into the water, and yet ſuch an egg being expoſed to congelation, the frozen water would be manifeſtly expanded, and ſwelled by numerous bubbles, which oftentimes gave it a whitiſh opacity.

To which we may add, that new metalline veſſels being filled with water, and carefully ſtopped, the liquor would nevertheleſs, when expoſed to the cold, be thereby expanded, and turned into ice furniſhed with bubbles.

5. If it be objected, that in the experiment of the hermetically ſealed glaſs, the produced bubbles might come from the air, which being ſealed up together with the water, might, by the expanſion of that water, be brought to mingle with it: I anſwer, that this is very improbable. For 1. if the bubbles muſt cauſe the expanſion of the water, how ſhall the water be at firſt expanded to reduce the air to a diviſion into bubbles? Next, it is evident by the experiments we ſhall ere long relate, that the air, as to the body of it, retains its ſtation above the water, and preſerves itſelf together in one parcel, ſince it ſuffers a compreſſion, that oftentimes makes it break the glaſs that impriſons it, which it would not need to do, in caſe it diſperſed it ſelf into the body of the water; for then there would appear no cauſe, why the air and water ſhould after congelation require more room than they did before. 3. In this experiment we uſually begin to produce ice and bubbles in the water, contiguous to the bottom of the veſſel (that part being by the ſnow and ſalt firſt refrigerated) in which caſe there appears no reaſon, why the air, which is a thouſand times lighter than the water, ſhould againſt its nature dive to the bottom of the water: and if it were diſpoſed to to dive, why ſhould we not ſee it break through the water in bubbles, as is uſual in other caſes, where air penetrates water? 4. In metalline veſſels, and in glaſſes quite filled with water, before they are ſtopped, there is no pretence of the diving of the air from the top, there having been none left there. 5. And laſtly, if all the bubbles of ice were made by, and filled with true air deſcending from the upper parts of the veſſels, and only diſperſed through the waters; then, upon the thawing of this ice, the air would emerge, and we might recover as much of the real air as would fill the ſpace acquired by the water upon the account of its being turned into ice, which is contrary to our experience. And this argument may alſo be urged againſt any, that ſhould pretend, (for I expect not to ſee him prove it) that though air, as numerous experiments evince, cannot get out of a ſealed glaſs, yet it may in ſuch a caſe as this, get into it. But we find upon trials, that the cavities of theſe bubbles are not any thing near filled with air, if they have in them any more air at all, than that little, which is wont, as we have elſewhere ſhewn, to lurk in the particles of water, and other liquors. And the making good of this leads us to the ſecond enquiry, we were propoſing about theſe bubbles; namely, whether or no their cavities be filled, and filled with air.

6. The full reſolution of this whole difficulty would be no eaſy matter, nor well to be diſpatched with ſo much brevity as my occaſions exact. For it would require ſatisfactory anſwers to more than one or two queſtions, ſince, for aught I know, it may lead us to the debate of thoſe two grand queries; whether or no nature admit a vacuum, and whether a great part of the univerſe conſiſt of a certain etherial matter, ſubtile enough to paſs through the pores, not only of liquors, but of compact bodies, and even of glaſs itſelf. We ſhould alſo be obliged to enquire, whether or no air, I mean true and permanent air, can be generated anew, as well out of common water, as many other liquors, and whether it may be generated by cold itſelf; and perhaps we ſhould be obliged to inquire into the *modus* of this production, and engage ourſelves in divers other difficulties, whoſe full proſecution, beſides that they would as much exceed our preſent leiſure, as abilities, ſeems more properly to belong to the more general part of phyſicks, where ſuch kind of general queſtions are fitteſt to be handled.

Wherefore we will now only conſider this particular queſtion, whether or no the cavities of the bubbles, wont to abound in ice, be filled with common air; and even this queſtion, though it ſeem but one, comprizes two: for to reſolve it, we muſt determine, whether there be any true air contained in thoſe cavities, and whether in caſe there be, they be adequately filled with that air, (by true air I mean ſuch an inviſible fluid, as does permanently retain a ſpring like the common air.)

7. The former of theſe two queſtions, I muſt confeſs myſelf not yet reſolved about, my experiments having not hitherto ſucceeded uniformly enough to ſatisfy ſo jealous an obſerver. But yet I ſhall annex our trials, not only becauſe the thing has not been, that we know of, ſo much as attempted by others, and our ways of experimenting, if they be duly proſecuted, ſeem as promiſing and hopeful if, the queſtion be reducible to any certain deciſion) as perhaps will be eaſily lighted on; but becauſe alſo we have, if we miſtake not, reſolved the ſecond queſtion, by ſhewing, that there is but a ſmall part of true air contained in the bubbles of ice, whatever ingenious men, that rely upon probable conjectures, without conſulting experience, have been pleaſed to believe to the contrary.

That the bubbles obſerved in ice cannot all be filled with the aërial particles lurking in the water, ſeems evident enough by the expanſion of the water, and the quantity of ſpace taken up by thoſe bubbles; which how the interſperſed, and formerly latitant air, can adequately fill, unleſs the ſame parcel of matter could truly fill much more ſpace at one time than at another; (which I take to be phyſically impoſſible) I do not yet apprehend.

But two ways of trial there are, which we employed to ſhew, that the icy bubbles are nothing near filled with true air, whether men will have that pre-exiſtent in the water, or ſtollen in from without, or generated anew; the former of the two ways of trials probably arguing, that theſe bubbles proceed not *only* (for that they may proceed *partly*, we do not

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at all deny) from the air pre-exiſtent in the water, and the latter concluding more generally, that but a ſmall part of the icy bubbles are filled with genuine air.

8. AND 1. we were invited to conjecture, both, that ſometimes, or in ſome caſes, the air latitant in the water might contribute to generate icy bubbles, though it was unable adequately to fill them; and again, that ſometimes or in other caſes ſuch bubbles would be almoſt as numerouſly generated, notwithſtanding the receſs of far the greateſt part of that latitant air, by the three following experiments taken *verbatim* out of our collections.

I. WE took fair water, and having kept it in the exhauſted receiver of our pneumatical engine for a good while, till we perceived it not to ſend up any more bubbles, we preſently transferred it into ſnow and ſalt, where it was long enough before it began to freeze; and then we obſerved, that the water did not ſwell near ſo much as common water is wont to do, and the ice ſeemed to have few or no bubbles worth taking notice of. But when I afterwards placed it between my eye and the vigorous flame of a candle, I could perceive, that it was not quite deſtitute of bubbles, though they were extremely ſmall, in compariſon of thoſe, that would probably have appeared in ordinary water.

THUS far the firſt experiment; the ſecond follows, which was made at another time.

II. THE water, that had been freed from the bubbles in the receiver, though it afforded an ice, that ſeemed to have ſmaller bubbles, yet this ice being thawed, part of the water was gently poured into a pipe of glaſs, wherein being frozen, it ſwelled conſiderably enough above its firſt level, and beſides burſt the glaſs, being alſo very opacous by reaſon of the bubbles.

THE third experiment was more induſtriouſly proſecuted, as may appear by this ample narrative of it, tranſcribed out of our Collections.

III. WE took a ſmall egg with a pretty long neck, and pouring in water till it reached an inch within the ſtem, conveyed it into a long ſlender cylindrical receiver, provided on purpoſe to make trials with ſuch tall glaſſes; the air being by degrees drawn out of the bubbles, appeared from time to time greater and greater, and when the receiver was well exhauſted, the water ſeemed to boil a longer time than one would have expected; and ſometimes the bubbles aſcended ſo faſt and great, that we were in doubt, whether the water did not boil over the top of the pipe. The exhauſted receiver was permitted to be ſo for a good while, till the water had diſcharged it ſelf in bubbles of its air, and then the glaſs-egg was removed into a veſſel furniſhed with ice and ſalt, and there left ten or twelve hours, that all the water, ſave that in the neck, might be throughly frozen; and then we found it to have riſen a great way above its firſt height: and removing it into an air tempered like that, wherein the firſt part of the experiment was made, and having left it there in a quiet place for ten or twelve hours to thaw leiſurely, (leſt too warm an air, or too much ſtirring the glaſs, might be an occaſion of generating new bubbles,) in the exteriour part of the ice near the glaſs, we ſaw pretty ſtore of bubbles; but when that was thawed, the reſt of the ice appeared of a peculiar and unuſual texture, having no determinate bubbles, that I could eaſily diſtinguiſh, but ſeeming almoſt like a piece of froſted glaſs, where the parts, that made the aſperity, were exceeding thick ſet; but this ice ſwam in the water, whereinto the reſt had been diſſolved before it was all thawed. When there yet remained a lump about the bigneſs of a ſmall walnut, we reconveyed it into the receiver, to try whether, upon the exſuction of the air, the ice would be preſently melted; but the alteration produced was ſo ſmall, if any, that we durſt not ground any thing upon it. The receiver being exhauſted, there did at length appear ſome bubbles in the water, but they were not numerous, and a hundred of them ſeemed not to amount to one of thoſe larger ones, the ſame water had yielded us the firſt time it was put in. In the ice alſo ſome ſmall bubbles diſcloſed themſelves, which we did not perceive there before; wherefore we took out the egg, and found (the ice being now thawed) that the water was ſubſided to the mark we had made, before it was expoſed to congelation, if not ſome very little way beneath it. Then we went about to find the proportion, wherein this diſpirited water was expanded by glaciation; but in purſuing this, there happened a miſchance to the glaſs, which kept the experiment from being ſo accurate as we deſigned. And therefore, though it ſeemed to us, that it amounted to about the twelfth part, which is leſs than that of the undiſpirited water, yet we deſigned the repetition of the experiment. Only in this we could not be miſtaken, that the expanſion was conſiderable, ſince the water roſe three inches and a half in the ſtem, though the whole water in the egg and ſtem too weighed but two ounces and a half. If the veſſel had not been unluckily cracked, we ſhould have frozen the water once more; and then ſealing up the glaſs hermetically, and ſuffering the ice leiſurely to thaw, ſhould have inverted it, and broken it under water, and have proceeded with it as we had done with ſome other glaſſes in the formerly mentioned experiments.

9. [A LITTLE glaſs cylinder open only at one end, of a convenient length, was thruſt into a deep and wide-mouthed glaſs, about half filled with a mixture of ice and ſalt: but the cylinder was neither ſo quite filled, that the water ſhould run over, nor yet far ſhort of being ſo; that (for all the opacous mixture of ice and ſalt) we might gueſs at the freezing of that part of the water, that we could not ſee by the changes appearing in the other. Then conveying all into a receiver, that we had in readineſs beforehand, we quickly pumped out the air, upon which there came, both from the upper and lower parts of the water, great ſtore of bubbles to the top, where moſt of them brake into a receiver. Having found, upon trials purpoſely made, that the engine had continued ſtanch all the while, and perceiving by the intumeſcence of the ſuperiour parts of the water, that the other were frozen, we let in the external air, and having removed the receiver,

and

and taken out the mixture, before the ice was half melted, we found the water, as high as the mixture reached, to be turned into ice, which, beſides ſome large and conſpicuous bubbles, had ſmall ones enough to render it opacous; and upon the account of this expanſion it was, that the water did in the free air continue a good deal higher than the mark, it was but level with, when the cylinder was expoſed to freeze.]

10. THE other way we employed to examine what was contained in icy bubbles, and which ſeemed clearly enough to manifeſt, that they are very far from being filled with true and ſpringy air, is intimated in the laſt clauſe of the foregoing narrative, but will be beſt underſtood by the annexed experiments, tranſcribed juſt as I find them regiſtered in my collections. And though they be prolix, and contain ſome few particulars, that make not directly for the purpoſe I alledge them for, yet I think not fit to diſmember or to epitomize them, or otherwiſe to alter any thing in them; partly, that the inference I make from them may be the leſs miſtruſted; partly, becauſe the way of experimenting being altogether new will be beſt apprehended by the ſubjoined examples; and partly too, becauſe thoſe particulars, that relate not directly to the occaſion of our mentioning theſe trials, may be uſeful to illuſtrate or confirm ſomething, that is already delivered, or is hereafter to be delivered in the preſent hiſtory of cold.

Feb. 4. 1661. 11. [WE took this day a glaſs of the form of an egg, but of double the capacity, out of whoſe obtuſe end roſe up a cylindrical neck, capable to receive the end of my little finger, and no more; this being filled with common water, till the liquor reached a pretty way within the pipe, and the ſurface of the water being carefully marked on the outſide, was placed in a veſſel, wherein ice very groſly beaten, was mingled with a convenient proportion of ſalt, (according to our way of glaciation) the mixture not reaching up to the mark by above an inch. The experiment afforded us theſe particulars.

I. A HEEDFUL eye did not perceive the water ſenſibly to ſubſide, before it began to freeze.

II. THE water began to ſwell, and ſome parts of it next the ſide or bottom of the glaſs, to freeze within a quarter of an hour.

III. THE aſcent of the water in the pipe increaſed ſo faſt, that within an hour, from the time the glaſs was put in, it did riſe four inches, and $\frac{2}{3}$ above the mark; and afterwards the ſwelling continued ſo, that we took it out, though a good part of the water remained unfrozen, it had reached five inches and ſomewhat more than a half above the firſt mark.

IV. THE ice and ſalt being purpoſely kept always beneath the ſurface of the water, the lower parts of the water were frozen, and never the upper ſurface.

V. DURING all this great elevation of the water, there appeared no bubbles worth taking notice of in the unfrozen parts of the liquor, but the ice was very full of them, divers of which toward the latter end of the experiment were very large bubbles, (but not all of them round) ſome being about the bigneſs of hail-ſhot, ſome ſmall like muſtard-ſeed, and others again not much inferiour to little peaſe.

VI. HAVING taken out the glaſs, when the water was at the higheſt mark, we did, upon a certain deſign, pour in as much ſallet-oil as ſwam about two inches above it, and then the glaſs was nimbly at the flame of a lamp ſealed up, during which time the included water ſubſided a little; but the glaſs being again put into the ice and ſalt, the cold quickly reſtored the water to its former height, and there remained about an inch and half of the ſealed glaſs unpoſſeſſed by the two contained liquors.

VII. THEN with a good pair of ſcales we weighed the glaſs-egg firſt in the air, and then in the water, (the better to diſcern, whether any ſhrinking of the glaſs intervened in the caſe,) where it hung freely, and was left hanging in its æquilibrium with its oppoſite weight.

VIII. WHILST it thus hung, upon the thawing of the ice many bubbles great and ſmall aſcended (the great ones with a wriggling motion) and vaniſhed at the top.

IX. AS the ice thawed, the water and oil deſcended, till the whole ice was returned to water; at which time we obſerved theſe two remarkable things; the one, that the æquilibrium remained the ſame; the other, (which was more conſiderable) that the water was ſubſided again as low as the firſt mark, with which it was level before it began to ſwell, without falling beneath it, notwithſtanding the receſs of ſuch a multitude of bubbles, divers of which were very large.

X. THE glaſs being inverted, the ſealed end, which was drawn ſlender, was gently broken under water, of which ſome, being impelled in, did ſenſibly reduce the air at the oppoſite end into a narrower room; and, as one of the ſpectators obſerved, into a much narrower, which is conſonant enough to reaſon.

XI. THE glaſs being again inverted, and held till it was ſettled, we found, that the water drawn in together with the water it found there, and the oil, poſſeſſed the ſame places, (as appeared by the marks in the cavity of the receiver,) that they did, when it was ſealed up.

XII. AND laſtly, having thrown out the oil, and employing, where need was, a little water of the ſame kind we had made uſe of all this while, we found the glaſs filled to the higheſt mark, to weigh 4374 grains; when it was filled but to the loweſt mark, 4152 grains; and when quite emptied, 1032. So that the water contained betwixt the higheſt and loweſt mark, and raiſed by the glaciation, was about a fifteenth part of the water ſet to freeze; and probably would have amounted to much more, if the water had been all frozen.

Dec. 11. 1662. 12. [A LARGE glaſs-egg being taken with a proportionably big ſtem, we poured water into it, till it reached about an inch above the bottom of the ſtem, and faſtening a mark there, we expoſed it all night to freeze in ſnow and ſalt; which was ſo placed, as not to reach ſo high

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high as the bottom of the ſtem. The next day about ten of the clock we found the water riſen in the ſtem about 15 inches above the mark, the whole cylinder of water being fluid by reaſon of the ſnow's not reaching to it. (Then upon a deſign, to be elſewhere mentioned, we ſealed up the glaſs by a very ſlender pipe, that had been before purpoſely drawn out to a pretty diſtance from the body of the cylinder, that the glaſs might be ſealed in a trice, before the flame of a candle could ſenſibly rarify the air, and after a while we broke off the apex of this ſlender pipe in proſecution of our former deſign.) Then ſuffering the water to ſwell freely, within ſeven or eight hours it reached the very top of the glaſs, a drop or two running over at the ſlender orifice thereof; ſo that in all, the water aſcended about 19 inches above the firſt mark. Then we tried by the flame of a candle to ſeal the glaſs, but by reaſon of the rarifaction of ſome of the water, by the heat, into vapours, by which ſome of the other water was, from time to time, ſpurted againſt the flame of the candle, we found it troubleſome enough to ſeal it up, the veſſel being removed into a warm place, till next morning; and all the ice in the belly of it (for the water in the ſtem continued fluid) being thawed, the water ſubſided, not only to its firſt mark, but a little beneath it, by reaſon of that which was thrown out, upon occaſion of the ſealing of the glaſs. But when we came to invert this, after the manner above mentioned, into a veſſel of water, to ſee how much of the ſpace deſerted by the thawed ice was filled with air, and how much was filled with a ſubtiler ſubſtance, or empty, juſt then a miſchance fruſtrated our expectation.]

Decemb. 13. [AN egg about the ſame bigneſs with the former was placed to freeze in beaten ice and ſalt, and in leſs than an hour, it was riſen near an inch above the mark, where the ſurface of the water was at the firſt, and the water in the ball and the joining of the neck was frozen into *laminæ*. After an hour and a quarter, thoſe *laminæ*, that before appeared in the beginning of the neck, now diſappeared; but the ball ſeemed frozen into a white ice, and the water in the neck was riſen above the firſt mark four inches and a half. There now appeared abundance of ſmall bubbles, continually aſcending through the neck, (which ſo continued all the time after, till it was quite thawed) and the white ice appeared full of bubbles. The experiment being further purſued, the water aſcended higher and higher, till it had reached about eight inches above the firſt mark: then the top of the pipe being with a lamp drawn out into a very ſlender cylinder (for the conveniency of ſealing up) the glaſs was again put into the ice, that the air heated by the lamp might cool; upon which the water continued ſwelling, till it began to run over at the orifice of the ſlender pipe, which being held by, in the flame of a candle, was in a trice ſealed up; ſo that the whole glaſs appeared full of water, bating an inconſiderable quantity of rarified air, (not amounting to the bigneſs of half a ſmall pea) that remained contiguous to the ſealed part. The egg being brought into a warm room, was kept there all night, and a good part of the next morning, before the ice was quite thawed; which when it was, the water was found ſubſided to the firſt mark, and which being done, the glaſs was inverted, and the ſealed end immerſed a good way under water; where being broken, the external air impelled the water in the baſon into the cavity of the pipe, inſomuch, that when we took it out, which we did, as ſoon as we thought no more water was impelled up, reinverting the glaſs, we found, that the admitted water reached ſeven inches above the firſt mark, and left an inch and an half of the ſtem, before it began to be wire-drawn, beſides as much of the ſlender part of the ſtem, as by gueſs amounted to a quarter of an inch more: ſo that it ſeemed, that the bubbles, which made the water ſwell, and appeared in the ice, amounted to an inch and three quarters of air, which conſequently ſeemed to be for the moſt part generated by this operation, and to ſeven inches either of a vacuum, or ſome ſubtile ſubſtance, which by its having no ſpring to reſiſt the preſſure of the outward air, appeared not to be air. We could not exactly meaſure the quantity of water we had in all, and the proportion of it betwixt the marks, becauſe having left the glaſs in the window, to try whether time or cold would make the admitted water ſhrink (which we did not find it to do) the weather was too ſharp, that beginning (as we concluded) to freeze the water in the ſtem, the increaſing ice burſt out the belly of the glaſs into many pieces.]

Another time.

14. [A ſealed glaſs being broken under water, there was impelled into the cylinder ten inches and a little above a half. And the mark it ſhould have riſen to, was eleven inches and a quarter above the firſt and loweſt mark.]

Another time.

Decemb. 15. [IN the ſame bolt-head, wherein the greateſt condenſation of the air was tried, the water was by the cold made to ſwell very near a foot above the mark it reſted at, when it began to freeze; then the glaſs being nip'd up, the contained water was removed, and ſuffered leiſurely to thaw, and upon the diſſolution of the ice, the water fell back to the former mark. Laſtly, the glaſs being inverted, the apex was broken off under water, and the water in the ſtem was, by the outward air preſſing, upon the water in the baſon, with ſome impetus and noiſe driven up into the cavity of the glaſs; and, the glaſs being ſeaſonably and warily removed from the baſon, we found there had been impelled up of the water in the baſon, a little more than eleven inches; ſo that there ſeemed to be near $\frac{7}{8}$ of an inch of air generated or ſeparated by the former operation.]

Another time.

Decemb. 16. IN the ſame glaſs we made the water to ſwell about ten inches, and inverting the ſtem, 17. and

and breaking the neb under water, we found about ten inches of water to have been impelled into the ſtem ; ſo that in this there ſeemed no generation of air.]

17. To all theſe experiments we ſhall ſubjoin, in two words, that as in water, ſo in ſome aqueous liquors we found, that the icy bubbles were not filled with air (though we did not think fit to take the pains to meaſure their reſpective expanſions by being congealed :) for in that elſewhere mentioned experiment, where we expoſed milk, urine, and Rheniſh-wine to freeze, when all thoſe liquors were riſen above their former marks, as is there related, our notes inform us, that the experiment was thus proſecuted.

18. [Being ſealed up (the foregoing words mentioned the above-named expanded liquors) and ſuffered to thaw, the ſeveral liquors ſubſided to their firſt marks or thereabouts, and the glaſſes being inverted and broken under water, we were, by an accident, hindered from obſerving what we deſired in that, which had the wine, though when it was taken out of the freezing pot, it had ice, but not much, ſwimming in it. But into the glaſs, that had the milk, the water was manifeſtly impelled by the outward air ; and ſo it was into the glaſs, that had the urine, which being removed from the baſon, and reinverted, appeared to have as much new liquor in its ſtem, as amounted by gueſs to five or ſix inches.]

19. To which experiment we may add, that another time a ſealed glaſs of partly frozen claret-wine being broken under water, the water was impelled up between half an inch, and an inch above the mark, beyond which it would not have aſcended, if the bubbles had been full of true and permanent air.

20. If it be ſaid, that though I have delivered too many particulars about ſo empty and ſlight a theme as bubbles, I have this to anſwer, that poſſibly all theſe experiments have rather ſhewed us, what it is not, that fills them, than what it is ; ſo that more than all theſe experiments appearing requiſite to clear up the difficulties about them, I ſhall not think I have altogether miſ-ſpent my time, eſpecially if ſo many paſt experiments, both new, and not altogether impertinent, by their not having taught us enough about ſo deſpicable a ſubject as a bubble, ſhall, as they juſtly may, teach us humility.

TITLE X.

Experiments about the meaſure of the expanſion and the contraction of liquors by cold.

1. TO the experiments (mentioned in the ſeventh and ninth titles) which ſhew, that water has an expanſion, it will be proper to ſubjoin ſome of thoſe, whereby we endeavoured to meaſure that expanſion. And here we ſhall not content ourſelves to ſay, that whereas the authors we had formerly occaſion to point at, take notice of their having raiſed water in a bolt-head half an inch or an inch by freezing, we have made it aſcend a foot and a half and more; this, I ſay, we ſhall paſs by, because that though by ſuch experiments we have very clearly and undeniably manifeſted the expanſion of the water, yet unleſs the capacity of the veſſel be known, they will ſignify but little towards the determining the quantity of that expanſion, which yet is the thing we are enquiring after: wherefore we ſhall add, that we employed two differing ways to meaſure this expanſion.

2. The one was, by putting in, by weight, ſuch a number of ounces of water into a bolt-head, till the water was riſen a pretty way in the long ſtem wherewith it was filled ; then marking on the outſide, to what height every freſhly added ounce of water reached in the ſtem, we afterwards poured out a convenient quantity of the liquor, (yet leaving enough to fill the whole cavity of the ſpherical or obtuſe end of the veſſel, and of the lower part of the ſtem ;) then leiſurely freezing this remaining water from the bottom upwards, we obſerved, that when it was frozen, the ice, that was made of 82 parts of water, filled, as one of our notes inform us, the ſpace of 91, and (if I miſtake not the character) an eighth ; ſo that by this troubleſome way of examination, we found, that the water, by the expanſion it received from cold, was made to poſſeſs about a ninth part more ſpace than it did before congelation.

[3. In another of our notes, we find as follows, 55 parts of water extended themſelves by freezing into 60 and $\frac{1}{2}$, about 6 of thoſe parts remaining unfrozen ; ſo that in this experiment the water's expanſion was not much (though ſomewhat) differing from what it was in that laſt mentioned.]

4. The other way we made uſe of to meaſure the dimenſions, that water gains by freezing, was to take a cylindrical pipe of glaſs, ſealed at one end, and left open at the other ; at which we filled it with water to a certain height, that we took notice of, by a mark applied to the outſide, and then keeping it in an erected poſture, and freezing it from the bottom upwards, we found, that it had acquired by a tenth part, or thereabouts, greater dimenſions in the form of ice, than it poſſeſſed in the form of water. But the nature of the particular parcel of liquor expoſed to the cold, (for it is not neceſſary, that all waters ſhould be equally diſpoſed to be expanded by freezing) and ſome other circumſtances, not now to be diſcourſed of, may well beget ſome little variety in the ſucceſs of this ſort of trials. For in one, that we made carefully, we found the expanſion ſomewhat greater, than that laſt mentioned, as may appear by the following note ; which, compared with what was lately delivered, of the trials we made by weight of the water's expanſion, may invite us to think, that we cannot much err by eſtimating in general, that the room, that ice takes up more than water, amounts to about a ninth part of the ſpace poſſeſſed by the ſame water, before it was turned into ice. The note we were ſpeaking of, is this :

[5. In a more than ordinarily even cylindrical glaſs, we expoſed ſome water to freeze,

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to meaſure its intumeſcence, and found, that it expanded itſelf to about an eighth part, or at leaſt a ninth upon glaciation; this we tried twice, and thought, that the intumeſcence might have been more conſiderable, but that in a cylinder the freezing did not ſeem to ſucceed ſo well.]

BUT here we muſt reſolve a difficulty, which, though ordinary readers may take no notice of, yet may breed a ſcruple in the minds of thoſe, that are acquainted with hydroſtatics. For to ſuch readers this account of ours may ſeem to be contrary to the experience of navigators into cold climates, who tell us (as we ſhall have occaſion to take notice of in due place) of vaſt pieces of ice, as high, not only as the poops of their ſhips, but as the maſts of them; and yet the depth of theſe ſtupendous pieces of ice ſeems not at all anſwerable to what it may be ſuppoſed to be, in caſe we compare together the eſtimate above delivered of the expanſion of water, and that grand hydroſtatical theorem demonſtrated by *Archimedes* and *Stevinus*, 'That floating bodies will ſo far, and but ſo 'far, ſink in the liquor, that ſupports them, 'till the immerſed part of the body be equal 'to a bulk of water, weighing as much as the 'whole body.' For Captain *James*, in his often-cited voyage, makes mention of great pieces of ice, that were twice as high as the top-maſt-head of his ſhip.

6. AND the Hollanders, in their famous voyage to *Nova Zembla*, mention one ſtupendous hill of ice; which I therefore take notice of here, not only becauſe it has been thought the greateſt, that men have met with, but becauſe they deliver its dimenſions, not as Captain *James* and navigators are wont to do, by compariſon with the unknown heights of ſome of the maſts of their ſhips, but by certain and determinate meaſures, which, in the icy iſland we are ſpeaking of, were ſo divided by the ſurface of the water, that there was 16 fathom extant above it, though there were but 36 beneath it; which, though a vaſt depth in itſelf, yet does but little exceed double the height.

Barthol. de nivis uſu, *Cap.* 6.

And the Daniſh navigator *Janus Munckius*, employed by his king to bring him an account of *Greenland*, mentions ſome floating pieces of ice, that he met with and obſerved in that ſea, which, though but ſomewhat above 40 fathom under water, were extant 20 fathom, (that is, near half as much) above water; whereas it ſeems, that, according to our above-mentioned computation of the expanſion of water, the part under the water ought to be eight or nine times as deep as that above the water is high.

7. TO clear this difficulty, I ſhall repreſent theſe three particulars:

FIRST, that in our computation, the ice, that ſinks ſo deep, is ſuppoſed to float in freſh water; whereas, in the obſervations of the above-named navigators, thoſe vaſt pieces of ice floated on the ſea-water, which by reaſon of its ſaltneſs, being heavier than freſh water, ice will not ſink ſo deep into that, as into this. And that ſalt may hugely increaſe the weight of the water, wherein it is diſſolved, may be clearly gathered from the ponderouſneſs of common brine, and from the practice of ſeveral ſorts of tradeſmen, who, to examine the ſtrength of their lixiviums, and other ſaline liquors, are wont to try, whether they will keep an egg floating, which we know common water will not do. And I have alſo, by the reſolution of ſome metalline bodies in fit menſtruums, made liquors, that are yet much more ponderous, than is ſufficient for the ſupport of eggs.

BUT yet we muſt be ſo candid, as to take notice of what ſome modern geographers deliver with probability enough; namely, that nearer the poles the ſeas are not wont to be ſo ſalt, as in the temperate and the torrid zones: and thoſe northern being not ſo ſalt as our ſeas, there is the leſs to be allowed for the difference in gravity (and conſequently in the power to keep ice from ſinking) betwixt thoſe ſeas and ours.

8. BUT ſecondly, this leſſer ſaltneſs of the water in the northern ſeas may, as to our caſe, be recompenſed by the greater coldneſs of it. For though, as we have formerly obſerved, the condenſation of freſh water, effected here by a degree of cold capable to make it begin to freeze, is not ſo great as moſt men would imagine; yet beſides that I have often taken pleaſure to make the ſame body to ſink or aſcend in the ſame water, by a much leſs variation of cold than that we have been mentioning; it is to be conſidered, that the degree of cold, to which water was brought in the experiment delivered in the fourth ſection, to which we are now looking back, was but ſuch a degree, as would make freſh water begin to freeze: whereas the ſalt ſea-water, being indiſpoſed to congelation, may, by ſo vehement a cold as reigns in the winter-ſeaſon in thoſe gelid climates, be far more intenſely refrigerated, and thereby more condenſed than common water is here, by ſuch a meaſure of cold, as may begin to freeze ſmall portions of it. But though what we have hitherto repreſented, may well be looked upon as not inconſiderable to the purpoſe, for which it has been alledged, yet the main thing, that is to remove the ſcruple ſuggeſted by the height of icy hills above the water, is,

9. THIRDLY, that ſuch hills of ice are not to be looked upon as intire and ſolid ones, but as vaſt piles or lumps, and maſſes of ice, caſually and rudely heaped up and cemented by the exceſſive cold, freezing them together by the intervention of the water, that waſhes them; which piles of many pieces of ice are not made without great cavities intercepted, and filled only with air, between the more ſolid cakes or lumps: ſo that the weight of theſe ſtupendous pieces of ice is not to be eſtimated by the bigneſs they appear of at a diſtance from the eye, but conſidering how much air there is intercepted between the icy bodies, of which they are compiled, there may be a hollow ſtructure of ice reaching high into the air, and yet the whole aggregate or icy pile, will preſs the ſubjacent water on which it leans, no more than would

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would as much water, as were equal in bulk only to the immerſed parts; as we ſee in barges loaden with boards, which, though piled up to a great height above the water, make not the veſſel to ſink more than a lading, that would make a far leſs ſhew, and oftentimes be all contained within the cavity of the veſſel, provided it be more ponderous *in ſpecie*. But to enter into any further conſideration of theſe hydroſtatical matters, would be improper in this place, eſpecially ſince we have * elſewhere treated of them. And that theſe floating hills and iſlands of ice are not intire and ſolid pieces of it, we ſhall otherwhere have occaſion to ſhew out of navigators, and even in the obſervation we have mentioned out of *Janus Munck*, the learned relator of it. *Bartholinus* takes notice, that thoſe vaſt pieces of ice (we have been mentioning) that reached 20 fathom above water, were compiled of ſtore of ſnow frozen together.

* *In our Hydoſtratical Paradoxes.*

Ex nive copioſa glaciata compacta.

10. THESE conſiderations may ſerve to render ſome account of thoſe ſtupendouſly tall pieces of ice, whoſe extant parts bear ſo great a proportion to the immerſed part, when the whole maſs does really float. But I confeſs I doubt, that not only in the examples we have alledged, but in other eminent ones of mountains of ice, if I may ſo call them, there may be a miſtake; and that the height of them above the water would be far leſs, and the depth under water far greater, if the ice had water enough to ſwim freely. For ſeamen, by reaſon of the difficulty, are not wont to meaſure the height of thoſe pieces, that float at liberty in the ſea. And as for thoſe, that are on ground, as their heights lie far more convenient to be meaſured, ſo the meaſurers not knowing how long they have been on ground, for aught I know, much of that admired height may be attributed to the ſnows, that from time to time fall very plentifully in thoſe frozen regions, and are compacted together, either by the ſun, whoſe beams ſometimes begin to thaw it, and ſometimes by the water of the waves that beat againſt the ice, and being congealed with the ſnow, does as it were cement the parts of it together, and ſometimes by both of theſe cauſes. So in the inſtance alledged out of Captain *James*, page 14. of pieces of ice, that were twice as high as his topmaſt-head; it is ſaid alſo, that they were on ground in 40 fathom. And in the other example mentioned out of *Bartholinus*, though there be 40 fathom attributed to the immerſed part of the ice, yet that meaſure is not excluſive of a greater; for it is ſaid, that the ice reached downwards above 40 fathom; and how much downwards, and whether as far as the ground, we are left at liberty to gueſs. And in that ſtupendous piece of ice recorded in the *Nova Zembla* voyage, to have been in all 52 fathom, that is 300 and twelve foot deep, though it be granted what they affirm, that it was 16 fathom above the water, which is almoſt a third part of the whole depth; yet I obſerve, that of this icy mountain it is ſaid, that *it lay faſt on the ground*. So that as on the one ſide it ſeems probable, that the upper part of iſlands of ice may be increaſed by ſnow; and, as I remember, that in that famouſly inquiſitive navigator Mr. *Hudſon*'s voyage for the diſcovery of the North-weſt paſſage, it is related, that his company was * 'ſo well acquainted with the ice, that when night, or foggy or foul weather took them, they would ſeek out the broadeſt iſlands of ice, and there come to anchor, and run and ſport, and fill water that ſtood on the ice in ponds very freſh and good.' So on the other ſide we know not, how much lower the Dutchmen's ice and Captain *James*'s would have reached into the ſea, in caſe the ground they reſted on, had not hindred them. For though one might probably think, that theſe are the greateſt depths, that any hills of ice have been obſerved to attain, (that mentioned by the *Hollanders* reaching 36 fathom beneath the water, and that mentioned by Captain *James*, no leſs than 40 fathom) yet I find in Mr. *Hudſon*'s voyage, that the Engliſh, in the bay that bears his name, met with more than one or two iſlands of ice, of a far greater depth under water. For among other things, the relator has this memorable paſſage; 'In this bay, where we were thus troubled with ice, we ſaw many of thoſe mountains of ice aground, in ſix or ſeven ſcore fathom water.' And if the ſea had been deep enough, even theſe ſtupendous moles of ice would probably have ſunk much lower, and ſo have leſſened the heights of the mountains.

* *Mr.* Hudſon's *voyage for the diſcovery of the North-weſt paſſage, written partly by Mr.* Abacuck Pricket.

11. I KNOW, that delivering the meaſure of the expanſion of water alone, I have not ſaid all, that may be ſaid about the expanſion of liquors; but becauſe, as it has not yet appeared to me, that any liquor is expanded by cold, unleſs by actual freezing; I doubted, whether aqueous liquors, as wine, milk, urine, *&c.* were otherwiſe expanded by congelation, than upon the account of the water or phlegmatick (and, in a ſtrict ſenſe, congealable) part contained in them; and whether it were worth while, for a man in haſte, to examine their particular expanſions. Notwithſtanding which, I would not diſcourage any from trying, whether or no, by the differing dilations or aqueous liquors, ſome of them of the ſame, and ſome of them of differing kinds, we may be aſſiſted to make any eſtimate of the differing proportions they contain, of phlegm, and of more ſpirituous or uſeful ingredients.

12. AFTER what has been hitherto delivered concerning the expanſion of liquors by cold, it may be expected we ſhould ſay ſomething of the meaſure of their contraction by the ſame quality. But as for water, which is the principal liquor, whoſe dimenſions are to be conſidered, I have formerly declared, that I could ſeldom or never find its contraction (in the winter ſeaſon when I tried it) to be at all conſiderable. And I ſhall now add, that having, for greater certainty, procured the experiment to be made by another alſo, in a bolt-head, the account I received of it was, that he could ſcarce diſcern the water in the ſtem to fall beneath its ſtation, (marked at the upper part of the pipe,) when the water in the ball was ſo far infrigidated

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dated as to begin to freeze. Though I will not deny, that in warmer climates, as *Italy* or *Spain*, the contraction of the water, a little before glaciation begins, may be ſomewhat conſiderable, eſpecially if the experiment be made in ſummer, or in caſe (either there or here) the water expoſed to freeze be put into a veſſel very advantageouſly ſhaped, or brought out of ſome warm chamber or other place, where the heat of the air, that ſurrounded it, had rarified it. But to examine the meaſures of contraction in the ſeveral liquors, and with the nice obſervations, that ſuch a work, to be accurately proſecuted, would require, would have taken up much more of my time than I was willing to imploy about a work, which I looked not on as important enough to deſerve it. And therefore I ſhall here add nothing to what I have ſaid under the title of the *Degrees of Cold*, touching the contraction of ſpirit of wine and oil of turpentine, by the differing degrees of that quality; and as for the condenſation of air, the vaſteſt fluid we deal with, I did indeed think fit to meaſure how much cold condenſes it. But the account of that experiment will be more opportunely delivered in * one of the following diſcourſes.

* *In the ſect. about the temperature of the air.*

TITLE XI.

Experiments touching the expanſive force of freezing water.

1. HAVING ſhewn, that there is an expanſion made of water, and aqueous bodies, by congelation, let us now examine how ſtrong this expanſion is, and the rather becauſe no body has yet, that we know of, made any particular trials on purpoſe to make diſcoveries in this matter; ſo that although ſome unhappy accidents have kept our experiments from being as accurate as we deſigned, (and as, God aſſiſting, we may hereafter make them) yet at leaſt we ſhall ſhew this expanſion to be more forcible, than has hitherto been commonly taken notice of, and aſſiſt men to make a ſomewhat leſs uncertain eſtimate of the force of it, than they ſeem to have yet endeavoured to enable themſelves to make.

2. AND (1.) we ſhall mention ſome experiments, that do in general ſhew, that the expanſion of freezing water is conſiderably ſtrong.

WE took a new pewter bottle, capable to contain, as we gueſſed, about half a pint of water, and having filled it top full with that liquor, we ſcrewed on the ſtopple, and expoſed it during a very froſty night, to the cold air; and the next morning the water appeared to have burſt the bottle, though its matter were metalline, and though purpoſely for this trial we had choſen it quite new, the crack appeared to be in the very ſubſtance of the pewter. This experiment we repeated; and it was one of thoſe bottles filled with ice, that had cracked it, which a noble virtuoſo would needs make me (who ſhould elſe have ſcrupled to amuſe, with ſuch a trifle, ſo great a monarch, and ſo great a virtuoſo) bring to his Majeſty, to ſatisfy him, by the wideneſs of the crack, and the protuberance of the ice, that ſhewed it ſelf in it, that the water had been really expanded by congelation.

3. We alſo tried, whether or no a much ſmaller quantity of water would not, if frozen, have the like effect; and accordingly, filling with about an ounce of water a ſkrewed pewter box (ſuch as many uſe to keep treacle and ſalves in) quite new, and of a conſiderable thickneſs, we found, that upon the freezing of the included water, the veſſel was very much burſt.

AFTERWARDS filling a quart bottle (if I miſtake not the capacity) with a congealable liquor, and tying down the cork very hard with ſtrong packthread, we found, that the froſt made the liquor force out the ſtopple, in ſpite of all the care we had taken to keep it down.

BUT afterwards we ſo well faſtened a cork to the neck of a quart bottle of glaſs, that it was eaſier for the congealing liquor to break the veſſel, than to thruſt out the ſtopple; and having for a great many hours expoſed this to an exceeding ſharp air, we found at length the bottle burſt, although it were ſo thick and ſtrong, that we were invited to meaſure the breadth of the ſides, and found that the thinneſt place, where it was broken by the ice, was $\frac{3}{16}$ of an inch, and the thickeſt $\frac{3}{8}$, that is, twice as much: we alſo by the help of the froſt broke an earthen bottle of ſtrong *Flanders* metal, of which the thinneſt part, that was broken, was equal, by meaſure, to the thinneſt part of the other.

4. BUT the above mentioned inſtances ſerving only to declare in general, that the expanſion of water by cold is very forcible, I thought fit to attempt the reducing of the matter ſomewhat nearer an eſtimate leſs remote from being determinate; and becauſe the water expoſed to congelation may be probably ſuppoſed to be homogeneous, we judged, that the quantity of it, may very much vary its degree of force; and becauſe ſome may ſuſpect, that the figure alſo may not be inconſiderable in this matter, we thought fit to make our trials in a braſs veſſel, whoſe cavity was cylindrical, and which, to make it ſtronger, had an orifice but at one of its ends; and whoſe thickneſs was ſuch, that we had reaſon to expect, that whilſt the top remained covered, but with a reaſonable weight, the included water would find it more eaſy to lift up that weight, than break the ſides. To this cylinder we fitted a cover of the ſame metal that was flat, and went a little way into the cavity, leaning alſo upon the edges of the ſides for the more cloſer ſtopping of the orifice: the cavity of this cylinder was in length about five inches, and in breadth about an inch and three quarters. This cylinder being filled top-full with water, and the cover being carefully put on, was faſtened into an iron frame, that held it erected, and allowed us to place an iron weight, amounting to 56 pound, or half a hundred of common Engliſh weight; which circumſtance I mention (becauſe the common hundred, that our carriers, *&c.* uſe, exceeds five ſcore by twelve.) But this veſſel being expoſed in a froſty night to the cold air, the contained water did not the next morning appear to be frozen, and the trial

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trial was another time that way repeated with no better ſucceſs, as if either the thickneſs or clearneſs of the metal had broken the violence of the external air's frigefactive power, or the weight, that oppreſſed the cover, had hindered that expanſion of the water, which is wont to accompany its glaciation.

WHEREFORE we thought it requiſite to apply to the outſide of the veſſel a mixture of ſalt, with ice or ſnow, as that, which we had obſerved to introduce a higher degree of cold than the air alone, even in very froſty nights; and though this way it ſelf, the glaciation proceeded very ſlowly, and ſometimes ſcarce at all, yet at length we found, that the water was by this means brought ſo far to freeze, that on the morrow the ice had on one ſide ſwelled above the top of the cylinder, and by lifting the cover on that ſide, had thrown down the incumbent weight; but in this trial the cover having been uniformly, or every where lifted up above the upper orifice of the cylinder, we repeated the experiment divers times, as we could get opportunity, ſometimes with ſucceſs, and ſometimes without it; and of one of the chief of our experiments of this ſort, we find the following account among our collections.

5. [THE hollow braſs weight, being about one inch and three quarters in diameter, and the braſs cover put on, was loaded with a weight of 56 pound upon the cover and expoſed to an exceſſively ſharp night: the next morning the cover and the weight were found viſibly lifted up, though not above (that we could diſcern) a ſmall barley-corn's breadth, but the thickneſs of the braſs cover was not here eſtimated, which was much leſs than half an inch, which, according to former obſervations, one might expect to ſee the ice aſcend. But that, which we took particular notice of, was, that the incloſed cylinder of ice, being by a gentle thaw of the ſuperficial parts taken out, appeared ſo full of bubbles, as to be thereby made opacous. Alſo when in the morning the cylinder was brought into my chamber, before the fire was made, the 56 pound weight being newly taken off, at a little hole, that ſeemed to be between the edge of the braſs and ice, there came out a great many drops of water, dilated into numerous bubbles, and reduced in a kind of froth, as if upon the removal of the oppreſſing weight the bubbles of the water had got liberty to expand themſelves; but this laſted but a little while.]

6. AFTER this the difficulty we have often met with in the placing of great weights conveniently upon the cover of a cylinder, and the expectation we had to find the quantity of the water we made uſe of, capable, upon its congelation, to lift up a much greater weight, invited us to make trial of its expanſive force, by ſomewhat a differing way; which was, to fit a wooden plug to the cavity of the cylinder, (after we had ſuffered it to ſoak a convenient time in water, that, ſwelling as much as it would before, it might be made to ſwell no more by the water, which would lie contiguous to it in the veſſel) and then to drive it forcibly in, till by conſiderable weights appended to the extant part of the plug, when the cylinder was inverted, we could not draw it out. The ſucceſs of one of theſe trials is thus ſet down in our collections:

7. [A PLUG was driven into the cavity of a braſs cylinder, firſt filled with water, the plug being alſo well ſoaked; then the cylinder being inverted, the plug took up half a hundred and a quarter of a hundred weight, and would poſſibly have taken up much more, and being expoſed to a very ſharp night, the freezing water thruſt out the plug about a barley-corn's breadth, quite round above the upper edge of the cylinder; and it freezing all that day and the next night, it was again expoſed, the plug not being yet taken out, and then the plug was beaten out a little more, namely, (in all) near a quarter of an inch.]

8. THUS we ſee, that the expanſive endeavour of the water forced a reſiſtance, at leaſt equal to that, which would have been made by a weight of 74 pound; and probably, as the note intimates, would have appeared able to do more, if we had had convenient weights and inſtruments, wherewith to have meaſured the ſtrength of the water's endeavour outwards, which ſome ſubſequent trials made us think very conſiderable; though not finding their events ſet down in our notes, we think it fit at preſent to leave them unmentioned.

BUT one thing there is in theſe trials, that I think not unworthy a philoſopher's notice, and his conſidering; namely, that this endeavour of the water to expand it ſelf is thus vigorous, though the uttermoſt term, to which it would expand it ſelf, in caſe it were not at all reſiſted, would be but to about a ninth, or at moſt an eighth part of the ſpace it poſſeſt before it began to freeze; whereas air may by heat (which *yet, we have elſewhere ſhewn, will not reduce it to any thing near its utmoſt expanſion) be brought to poſſeſs (though not to fill) according to the diligent † *Merſennus*'s obſervation, ſeventy times the dimenſions it had before rarifaction; and conſequently the air expanded by heat does by its endeavours tend to acquire above 60 times the ſpace, that the water does, when expanded by ſo high a degree of cold, as is capable to turn it all into ice: not to mention, that the expanſion, to which the air tends upon the account of its own ſpring, is, (as we ſhew in another ‡ place) many times greater than that, to which *Merſennus* could bring it upon the bare account of heat.

* *New Experiments Phyſico-mech. Exper. 6.*

† *See the fore-cited place.*

‡ *The Appendix to the Phyſico-mechanical Experiments.*

9. THERE remains yet one way, whereby we hoped, though not to meaſure the expanſive force of freezing water, yet to manifeſt it to be prodigiouſly great; or in caſe we failed of this aim, to produce at leaſt ſome other phænomena relating to cold, that would not be inconſiderable. And though our endeavours ſucceeded not, yet becauſe a happier opportunity may bring them to be one way or other ſucceſsful, we ſhall annex, that we cauſed to be made an iron ball of between two and three inches diameter; which ball was ſolid, ſave that in the midſt there was a ſmall cavity left to place a little water in, together with a female ſcrew,

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as they call it, reaching from the outward ſurface of that internal cacity; and to this was applied a ſtrong iron ſcrew, ſo fitted to the internal cavity of the other ſcrew, as to fill it with as much exactneſs as could be obtained. And this ſcrew was made to go ſo hard, that it required to be ſcrewed in by the help of a vice, that it might not be forced out, without breaking the iron it ſelf. Our deſign in imploying this inſtrument was, that having well filled the internal cavity with water, and forced in the ſcrew as far as it could be made to go, the inſtrument thus charged with water might be expoſed to the higheſt degree of cold we could produce. For having thus ordered the matter, we thought we might expect, either that the water, how much ſoever we heightened and lengthened the cold, would not freeze at all, being hindered from the expanſion belonging to ice in compariſon of water; or, if it did freeze, that one of theſe two things would happen, either that the expanſive force of that little water would, by forcing ſuch an iron inſtrument, manifeſt its ſtrength to be ſtupendous; or, by not breaking it, preſent us with ice without bubbles, or at leaſt not rarer and lighter, than the water it was made of: but for want of a ſufficient cold, our deſigns ſucceeded not, ſo as to ſatisfy us, though we more than once attempted it. For the great thickneſs of the iron being conſidered, we were not ſure, that the waters not freezing might not proceed rather from the thickneſs and compactneſs of the metal, than from its reſiſtance to the expanſion of water. And therefore we muſt ſuſpend the inferences, this experiment may afford us, till we have opportunity to make trial of it, with a cold not only very intenſe, but durable enough; the want of which laſt circumſtance keeps us from daring to build any thing on our experiment.

10. AND here we may take notice, that it may be an inquiry, more worthy a philoſopher, than eaſy for him, whence this prodigious force, we have obſerved in water, expanded by glaciation, ſhould proceed. For if cold be but, as the Carteſians would have, a privation of heat, though by the receſs of that ethereal ſubſtance, which agitated the little eel-like particles of the water, and thereby made them compoſe a fluid body; it may eaſily enough be conceived, that they ſhould remain rigid in the poſtures, wherein the ethereal ſubſtance quitted them, and thereby compoſe an unfluid body like ice: yet how theſe little eels ſhould by that receſs acquire as ſtrong an endeavour outwards, as if they were ſo many little ſprings, and expand themſelves too with ſo ſtupendous a force, is that, which does not ſo readily appear. And on the other ſide, in the Epicurean way of explicating cold, though the phænomenon ſeems ſomewhat leſs difficult, yet it is not at all eaſy to be ſolved: for though, granting the ingreſs of ſwarms of cold corpuſcles, the body of water may be ſuppoſed to be thereby much ſwelled and expanded, yet beſides that theſe corpuſcles, ſtealing inſenſibly into the liquors they inſinuate themſelves into, without any ſhew of boiſterouſneſs or violence, it is not ſo eaſy to conceive, how they ſhould diſplay ſo ſtrange a force againſt the ſides of thoſe ſtrong veſſels, that they break, when they may as freely permeate or enter them: beſides this, I ſay, we obſerve, that in oil, which requires a far greater degree of cold to be congealed to a good degree of hardneſs, the ſwarms of frigorifick atoms, that invade it, are ſo far from making it take up more room than before, that they reduce it into leſs, as may appear by thoſe former experiments, which manifeſted, that cold does not expand, either oil or uncongealable liquors, but condenſe them.

11. AFTER what I have thus largely delivered, concerning the expanſive endeavour of freezing water, I hope I may be allowed to leave to others (if they ſhall think it worth the labour) the proſecution of the like experiments upon wine, milk, urine, and other liquors abounding with aqueous parts; concerning which, we ſhall only in general remind thoſe, that may have forgotten it, that by ſome of our experiments it appears, that ſuch aqueous liquors are expanded by congelation, and that their endeavour outward is conſiderably forcible, ſeems more than likely from what we formerly noted out of the Dutch voyage to *Nova Zembla*, where it is related, that by the extreme cold, both ſome of their other barrels, and ſome of thoſe that were hooped with iron, were, as they ſpeak, frozen in pieces; that is, according to our conjecture, burſt together with the hoops, whether of wood or iron, by the expanſive force of the impriſoned liquors brought to freeze.

12. To which I ſhall add, that when I aſked an ingenious perſon, whether in *Ruſſia*, where he lived a good while, beer and wine did not, when brought to congelation, break the veſſels they were frozen in; he anſwered, that he had not obſerved wooden veſſels to have been broken by them, (perhaps becauſe of their yielding) but glaſs and ſtone bottles often.

TITLE XII.

Experiments touching a new way of eſtimating the expanſive force of congelation, and of highly compreſſing air without engines.

1. THERE is yet another way, that I bethought my ſelf of, at once to meaſure the force, wherewith freezing water expands it ſelf, and to reduce the air to a greater degree of condenſation, than I have as yet found it brought to by any unqueſtionable way of compreſſing it. But whereas by this method, to determine exactly the expanſive force of the water, it were requiſite not only to know the quantity of the water, and that of the air expoſed to the cold, but to make the experiment in veſſels conveniently ſhaped to meaſure the dilatation of the one, and the compreſſion of the other; our experiments being made in a place, where we were not provided of ſuch glaſſes, we were not able to make our trials ſo inſtructive and ſatisfactory, as elſe we might have done. Nevertheleſs, we ſhall not ſcruple to ſubjoin thoſe of them, that we find noted down among our collections, allowing our ſelves to hope, that

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will not be unacceptable or appear impertinent, not only upon the account of their novelty, but for two other reaſons,

2. THE firſt, becauſe though they do not accurately define the expanſive force of freezing water, yet they manifeſt, that it is wonderfully great, better perhaps than any experiment, that has been hitherto practiſed, (not, to ſay, thought of;) as may appear by comparing what we have delivered in another treatiſe, of the great force requiſite to compreſs air conſiderably, with the great compreſſion of air, that has already been this way effected.

3. THE ſecond, becauſe this new way affords us one of condenſing the air much farther than hitherto it has, by any method I have heard of, been unqueſtionably reduced; I ſay, unqueſtionably, becauſe though the diligent *Merſennus*, and others, ſeem to have conceived himſelf to have reduced it in the wind-gun into a very narrow room; yet beſides that, by our expedient, we have compreſſed it beyond what theſe ingenious men pretend to; beſides this, I ſay, I have long much queſtioned, whether the way of compreſſing air in a wind-gun, which both they and we have imployed, may ſafely be relied on. For the oil or ſome other analogous thing, that is wont this way to be employed, and the overlooking of ſeveral circumſtances, that are more neceſſary to be taken into diligent conſideration, than wont to be ſo, may eaſily enough occaſion no ſmall miſtake in aſſigning ſo great a degree to the compreſſion of the air; but our exceptions againſt this way of meaſuring it may be more opportunely diſcourſed of in another place. And therefore we will now proceed to take notice, that of the two known ways of compreſſing air, the cleareſt and moſt ſatisfactory ſeems to be that, which is performed in the wind-fountain, as it is commonly called, where yet I have ſeldom, if ever, ſeen the air, (that I remember) by all the violence men could uſe to ſyringe in water, crouded into ſo little as the third part of the capacity of the veſſel. And an ingenious artificer, that makes ſtore of theſe fountains, being conſulted by me, about the further compreſſing of air in them, he deterred me from venturing to try it, by affirming to me, that both he and another ſkilful perſon of my acquaintance had like to have been ſpoiled by ſuch attempts: for endeavouring to urge the air beyond a moderate degree of compreſſion, it not only burſt ſome fountains made of glaſs, but when the attempt was made in a large, but thick veſſel, made of ſtrong and compact *Flanders* earth (the ſame with that of jugs and ſtone bottles) the veſſel was, by the over-bent ſpring of the air, burſt with a horrid noiſe, and the pieces thrown off with that violence, that if they had hit him, or his friend, that aſſiſted him in theexperiment, they might have maimed him, if not killed him out-right. So that the greateſt unqueſtionable compreſſion of the air ſeems to have been that, recorded in the fifth chapter of our defence againſt the learned *Linus*, where, nevertheleſs, we could reduce the air by the weight of a cylinder of mercury of about 100 inches, (which conſequently might near countervail a cylinder of ſixſcore foot of water) but into a little leſs than a fourth part of its uſual extent; but how much further the air may be compreſſed by our new purpoſed way, it is now time to ſhew by the enſuing notes, of which we have not omitted any, that we could find, both that ſome ſcruples, which might elſe ariſe about the way we employed, may be prevented or ſatisfied; and that the way, we imployed in practiſing this method, might by ſome variety of examples be the better underſtood.

[4. WE took a large glaſs-egg, with a cylin- *December* drical ſtem about the bigneſs of my little finger, 13. and pouring in water, till it reached about a finger's breadth higher than the bottom of the ſtem, we ſet it to freeze in ſnow and ſalt, for ſome hours, with the ſtop of the ſtem (which was drawn out into a very ſlender pipe, almoſt at right angles with the ſtem) open, and there left it for ſome hours, and the water was riſen betwixt ſix and a half, and ſeven inches. This we did in order to another experiment; but then eaſily and nimbly ſealing up the ſlender pipe above-mentioned, that the air in the ſtem might not be heated, we let it continue in the ſnow ſome time, adding freſh for about 24 hours, to obſerve to what degree the water, by expanding itſelf, would compreſs the impriſoned air. The length of the cylinder of air to be condenſed at the time of the ſealing, was (accounting by eſtimation for the ſlender pipe newly taken notice of) almoſt $9\frac{7}{8}$ inches. This ſpace we obſerved the aſcending water, as the ice increaſed below, to invade by degrees; (for we watched it, and meaſured it from time to time:) ſo much, till at length the water reached to 8 inches and $\frac{7}{8}$ almoſt, above the ſtation (which we had carefully marked with a diamond) in which we found it, when the glaſs was ſealed up, leaving but about an inch of air at the top; ſo that of the whole ſpace before poſſeſſed by the air, the water had intruded into near nine parts of ten. Then being partly apprehenſive the glaſs would hold no longer, but have its upper part blown off, as it happened to us a little before with another veſſel, and partly being deſirous to try that which follows, we leiſurely inverted the glaſs, that the air might get up to the ice; for all the water in the ſtem had been purpoſely kept unfrozen: and having provided a jar to receive the water, that ſhould be thrown out, we broke the ſlender pipe, which we had ſealed up, and immediately, as we expected, the compreſſed air, with violence and noiſe, blew out of the ſtem into the jar about ten inches of water; which was ſomewhat more (between half an inch and a whole inch, by reaſon of the *impetus* of the ſelf-expanding air) than the ſpace poſſeſſed by the air, before it began to be compreſſed. And beſides this, ſuch a ſtrange multitude of bubbles, that were formerly repreſſed, did now get liberty to aſcend from the lower parts of the glaſs to the top of the remaining water, that it ſomewhat emulated that, which happens to bottled beer; upon the taking out of the cork, *N.B.* when the air was compreſſed

compreſſed beyond ſeven inches, we obſerved divers times, that the inſide of the glaſs poſſeſſed by the air, and neareſt to the water, was round about, to a pretty height, full of very little drops like a ſmall dew; but when we came to break the glaſs, we took no ſuch notice, whether the riſing water had licked them up, or their concourſe made them run down into it, or for ſome other reaſon, we determine not.]

Another.

December 13. [5. WE took a ſingle phial filled with water, about half an inch above the lower part of the neck, and leaving about two inches of air in the remaining part of the neck, which was drawn out in a ſlender pipe, like that of the glaſs laſt mentioned, we ſealed it up, the air being firſt well cooled; and expoſing it to freeze, we obſerved a while after, that it had by gueſs condenſed the air into leſſer room. A while after, being in another chamber, we heard a conſiderable noiſe, and imagining what it was, we went directly to the glaſs, whoſe upper part conſiſting of about an inch of the neck, beſides the ſlender pipe, we found had been blown off from the table upon the ground, the body and part of the neck remaining in the ſnow; but this glaſs was of a metal, that uſes to be more brittle than white glaſs.

Another.

[6. A ROUND white glaſs, almoſt filled with water, was ſealed up with care, to avoid heating the included air, which amounted to a cylinder of about 2 inches and $\frac{7}{8}$; after a while the water ſwelled and compreſſed the air almoſt two inches, that is, full two thirds: and then (as we conjectured, becauſe the ſnow reaching too high, froze it in the neck) we found the glaſs cracked in many places of the ball, and the top thrown off at ſome little diſtance from it.]

Another.

[7. A LARGE ſingle phial ſealed, in whoſe neck the air was not condenſed to half its former room, juſt as we were going to break it under water, to obſerve the ſally of the compreſſed air, ſuddenly blew off with a good noiſe, and threw from the table almoſt the whole neck of the phial in one intire piece, which is near four inches long, and at the baſis above an inch broad.]

[8. A GLASS about the bigneſs of a turkey-egg, and of an oval form, with a neck almoſt cylindrical, but ſomewhat wider at the lower than the upper part, was filled with water, till there was left in the neck four inches and a half; whereof the laſt quarter of an inch, and a little more, was much narrower than the reſt, being drawn into a conical ſhape, that it might be eaſily ſealed at the apex; along this cylinder, from the ſurface of the water to the top of the glaſs, was paſted a liſt of paper, divided into inches and quarters: and then the glaſs being carefully and expeditiouſly ſealed up by the flame of a candle, we obſerved, that by holding the glaſs a while in a warm hand, and a room, where there was a good fire, the water was ſwelled up near a quarter of an inch; but placing the glaſs amongſt ſolid pieces of ice mixt with ſalt, the water quickly began to ſubſide upon the infrigidation; and a while after beginning to freeze, it began to ſwell, and by degrees compreſſed the air, till it had crouded it into leſs then a 17th part, by what ſeemed indiſputable; for by eſtimate, it ſeemed to ſome to be crouded into leſs than a 20th part, if not a much leſſer part, of the room it formerly poſſeſſed. Which difference of eſtimates, notwithſtanding the divided paper, proceeded from the change of the figure of the upper end of the glaſs, from the cylindrical, and to ſhew that there was no leak at the place where the glaſs was ſealed; beſides that by prying diligently, we could diſcern none; beſides this, I ſay, when the preſſure of the thus crouded air grew too ſtrong for the reſiſtance of the glaſs, it burſt with a noiſe, that made us come to it from ſeveral places of the houſe. The veſſel broke not in the cylindrical part (as I may ſo ſpeak) but in the oval, the whole pipe with the ſealed end remaining entire; the ice appeared full enough of bubbles, which made it white and opacous, and the water, that had aſcended into the neck, upon the breaking was all driven out of it.

THUS far our collections; but becauſe we had in another glaſs, where the operation was ſooner diſpatched, an opportunity of watching and obſerving ſomewhat more exactly, we will add,

9. THAT the laſt, and poſſibly the beſt experiment we had of compreſſing air by freezing, was made in a ſhort and ſtrong glaſs-egg, whoſe ball was very great in proportion to the ſtem, that the expanding of the water might have the more forcible operation. This veſſel being exactly ſealed, and having a divided liſt of paper paſted along the ſtem, was ſet to freeze with ſnow (or ice) and ſalt, and the contained water did quickly begin to croud the air into a leſſer room, and for a good while aſcended very faſt; till at length it having thruſt the air into ſo ſmall a part of the cavity of the pipe, that we vehemently ſuſpected there might be ſome unheeded flaw or crack of the glaſs, at which the air had ſtolen out, we drew near the veſſel, and attentively prying all about it, to try, if we could diſcover any ground of our ſuſpicion, we found (as far as the divided liſt, and other circumſtances could inform us) that the air (ſuppoſing none of it to have got away) was reduced by our eſtimate into the 19th part of the ſpace it poſſeſſed before. And this our curioſity proved not unſeaſonable; for whilſt we were narrowly ſurveying the glaſs, to ſpy out ſome flaw in it, we were quickly ſatisfied there had been none, by a huge crack made upon the eruption of the included air, whoſe ſpring being, by ſo great a compreſſion, made too ſtrong for the glaſs to reſiſt, it did with a great noiſe break the ball of the glaſs into many pieces, throwing the unfrozen part of the water upon me, and alſo throwing off the ſtem of the egg, which yet I had the good fortune to recover intire, and which I yet keep by me as a rarity.

10. THUS

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10. Thus far we then proceeded in compreſſing the air, which being done in veſſels hermetically ſealed, where no air can get in or out, ſeems to me a more unexceptionable way than thoſe, that have hitherto been thought of. But further, we could not then proſecute it for want both of convenient glaſſes, and of ice or ſnow, of which if we were provided, and particularly of ſtrong glaſſes, we ſhould little doubt of reducing the air to a yet more conſiderable degree of compreſſion.

11. We may add on this occaſion, that we looked upon the ſame way, as ſomewhat leſs unpromiſing than others, that have been hitherto uſed to try the compreſſion of water: for though hitherto neither the experiments of ingenious men, nor thoſe made by our ſelves, have fully ſatisfied us, that water admits any more compreſſion, than it may ſuffer upon the account of the little parcels of air, that are wont to be diſperſed among it; yet the unſucceſsfulneſs may perhaps (for I propoſe it but as a mere conjecture) be imputed to the porouſneſs of the veſſels; wherein, by the ways already practiſed, the experiment muſt be made: whereas in this new way of ours, not only the force, wherewith the compreſſed air preſſes upon the water, grows at length to be exceeding great, and is applied not with a ſudden impetus, as when a pewter veſſel is knocked with a hammer, but by ſlow and regular degrees of increaſe; but the water is kept in a veſſel impervious to its ſubtileſt parts, ſo that it may indeed crack the glaſs, but cannot get out at the pores, as the water compreſſed is wont to do at thoſe of metalline veſſels. The proſecution of this experiment, to bring it to any thing of accurateſneſs, we omitted, partly through forgetfulneſs and avocations, and ſometimes for want of conveniency to try it. But by the firſt of the lately mentioned experiments, about the condenſation of air, it ſeems by the ſtrong multitude of bubbles, which upon the breaking of the glaſs appeared in the water, that had been compreſſed betwixt air and the ice, that thoſe two bodies had very violently compreſſed it. And this we are the more apt to believe, becauſe that another time, when we had ſealed up ſome air and water in a glaſs-egg, and permitted the water to ſwell by the operation of the cold, but till it had reduced the air, included with it, to about three quarters of the ſpace it poſſeſt before; even then (I ſay) to try, whether the ſubjacent water were not alſo compreſſed by the air it urged, we broke off the ſealed apex of the glaſs, and perceived, as we expected, the water to aſcend, and that to the height of a quarter of an inch, as we found by meaſure. But ſuch trials having not been, as we juſt now acknowledged, duly proſecuted, we ſhall at preſent content our ſelves to have named this way of attempting the compreſſion of water, without grounding any inferences upon it.

TITLE XIII.

Experiments and obſervations touching the ſphere of activity of cold.

1. The ſphere of activity of cold, or, to ſpeak plainer, the ſpace, to whoſe extremities every way the action of a cold body is able to reach, is a thing very well worth the enquiring after, but more difficult to find, than at firſt one would imagine. For to be able to aſſign the determinate limits, within which, and not beyond them, a cold body can operate, ſeveral things are to be taken into conſideration: as firſt, what the degree of cold is, that belongs to the aſſigned body. For it ſeems rational to conceive, that if a cold body, as ſuch, have a diffuſive virtue, thoſe, that have greater degrees of cold, as ice and ſnow, will be able to diffuſe it to a greater diſtance, as we ſee, that a coal of fire will caſt a ſenſible heat much further than a piece of wood, that is heated without being kindled. Secondly, the medium, through which the diffuſion is made, may help to enlarge the bounds, or ſtraighten the limits of it, as that medium is more or leſs diſpoſed to receive or to tranſmit the action of the cold agent. Thirdly, Not only the conſiſtence, and texture of the medium, but its motion, or reſt, may be conſidered in this caſe. For in froſty and ſnowy weather, men obſerve the winds, that come from frozen lands, to blow more cold, than winds from the ſame quarter would do, in caſe there were no ice nor ſnow in their paſſage. Fourthly, There may be made very differing eſtimates of the diffuſion of cold, according to the inſtrument, that is imployed to receive, and acquaint us with the action of cold. For a liquor or other body may not appear cold to him, that examines it with a weather-glaſs, whilſt he ſhall feel it cold with his hand; and as we elſewhere alſo note, to that ſenſory it ſelf, as it is variouſly diſpoſed, the ſame object will ſeem more or leſs cold; ſo much may the prediſpoſition of the organ impoſe upon the unſkilful or unwary. Fifthly, The very bulk of a cold body may very much inlarge or leſſen its ſphere of activity, as we may have occaſion to ſhew ere long. And beſides, there may be divers other things, that may render it very difficult to aſcertain any thing in this matter. And therefore I ſhall reſerve them for other opportunities, and obſerve now in general, that in ſuch ſmall parcels of ice itſelf, as in our experiments we are wont to deal with, we have found the ſphere of activity of cold exceeding narrow, not only in compariſon of that of heat in fire, but in compariſon of the atmoſphere, if I may ſo call it, of many odorous bodies; as muſk, civet, ſpices, roſes, wormwood, aſſa dulcis, aſſa fœtida, caſtoreum, camphire, and the like; nay, and even in compariſon of the ſphere of activity of the more vigorous loadſtones: inſomuch that we have doubted, whether the ſenſe could diſcern a cold body, otherwiſe than by immediate contact.

2. And to examine this, having taken a piece of ice, we did not find upon trials, that I partly made my ſelf, and partly cauſed in my preſence to be made by others, that if a man's eyes were cloſe ſhut, he could certainly diſcern the approach of a moderately-ſized piece of ice, though held never ſo near his fingers ends. Nay, which is more conſiderable, having had the curioſity to make the trial, with one of thoſe very ſenſible thermoſcopes I have

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formerly mentioned (wherein a pendulous drop of liquor plays up and down in a ſlender pipe) I found, that by holding it very near to little maſſes of ſnow (ſomewhat compacted too) the moveable drop did not betray any manifeſt operation of ſo cold a neighbouring body; but if the glaſs were made to touch the ſnow, the effect would then be notable, by the haſty deſcent of the pendulous drop, or its motion towards the obtuſe part of the inſtrument, in caſe that were not perpendicularly, but laterally applied to the ſnowy lumps. But this languidneſs of operation may perhaps proceed in great part from the ſmallneſs of the pieces of ice, that were imployed; for hearing of a merchant, that had made divers obſervations about cold in *Greenland*, I deſired, by the mediation of a very learned friend, to be informed, whether or no in the night they could perceive thoſe vaſt heaps, or rather mountains of ice, that are wont to float up and down in that ſea, by any new and manifeſt acceſſion of cold, and was informed by way of anſwer to that queſtion, that being at ſea, they could know the approach of ice, as well by the increaſe of cold, as by the glaring light which the air ſeemed to receive from the neighbouring ice.

3. BUT that, which makes me ſuſpect, that there may in this account be ſome miſtake, is, that I have not yet met with any like obſervation in any of the voyages into gelid climates, that I have had occaſion to peruſe, though in ſome of them the navigators frequently mention their having met with vaſt rands (as ſome call them) and iſlands of mountainous ice in the night. And it is, as I remember, the complaint of one or two, if not more of them, that the ſhip lay cloſe by ſuch vaſt pieces of ice, without their being aware of it, by reaſon of the fogs. By which it ſeems, that there was no ſenſible cold diffuſed to any conſiderable diſtance, whereby they might be advertiſed of the unwelcome neighbourhood even of ſo much ice, but poſſibly the approach of far ſmaller maſſes of ice would have been ſenſible to them in ſuch a climate as ours, where the organs would not have been indiſpoſed to feel, by a long accuſtomance, any thing of near ſo intenſe a degree of cold, as that which then reigned in thoſe northern ſeas.

4. WHILST we were conſidering the difference betwixt the operations of even the coldeſt bodies at the very neareſt diſtance, and upon immediate contact, we thought it an experiment not altogether unworthy to be tried, whether, though ice and ſnow alone, that is, unaſſiſted by ſalts, would not in ſome of our formerly mentioned experiments freeze water, through the thickneſs even of a thin glaſs, they may not yet do it when the water is immediately contiguous to them. And I remember, that we took a conveniently ſhaped glaſs, and having frozen the contained water for ſome hours, from the bottom upwards, till the ice was grown to be of a conſiderable thickneſs, we marked what part of the glaſs was poſſeſſed by the unfrozen water; and then removing the veſſel to a little diſtance from the ſnow, and ſalt, it ſtood in before we let it reſt there, to try whether the ice would freeze any part of the contiguous and incumbent water; but ſome intervening accidents hindred us from being able to derive any great ſatisfaction one way or other from our trial.

5. WHEREFORE we ſhall add, by way of compenſation, that the diligent *Olearius* relates, that at *Iſpahan*, the capital city of *Perſia*, though it be ſeated in a very hot climate, and though it ſeldom freeze there above a finger thick, and the ice melt preſently at ſun-riſing, yet the inhabitants have conſervatories, which they furniſh with ſolid pieces of ice of a good thickneſs, only by pouring at night great ſtore of water, at convenient intervals of time, upon a ſhelving floor of free-ſtone or marble; whereon, as the water runs over it, the moſt diſpoſed of its parts are in their paſſage arreſted, and frozen by the contiguous ice, which by this means (ſays my learned author) may be brought in two or three ſucceſſive nights to a very conſiderable thickneſs. *Voyage de Moſcovie & de Perſe, Liv. V.*

6. WE ſeveral times gave order to have this experiment tried in *England*; but *partly* through the negligence of thoſe we employed, and *partly* upon the ſcore of intervening circumſtances, our expectation was but ill anſwered. And in this caſe I mention *intervening circumſtances*, becauſe having cauſed a ſervant to pump in the night, upon a not very thin plate of ice, that was laid ſhelving upon a board, and another flat piece of ice being about the ſame time laid under a place, where water derived from a neighbouring ſpring is wont continually to drop, he brought me word, that not only in this laſt named place, the ice melted away, but that under the pump, inſtead of increaſing in thickneſs by the waters running over it, it was thereby rather diſſolved. At which ſomewhat wondering, I went in the morning myſelf to the pump, and cauſing a good piece of ice to be in a convenient poſture placed under it, I obſerved the water, as it came out of the pump, and was falling on the ice, to ſmoak, as if the depth of the well had made the water, though very cold to the touch, ſomewhat warm in compariſon of the ice, and thereby fitter to diſſolve than to increaſe it; (which inconvenience may be prevented by ſuffering the water of deep ſprings and wells to ſtand to cool in the air, before it be put to the ice:) and this, though the neighbouring air were, as I found by manifeſt proofs, ſo cold, that I was not tempted to impute the unſucceſſfulneſs of the experiment, rather to its want of a ſufficient coldneſs, than the water's. So that till I have an opportunity of making a further trial, I cannot ſay more to the *Perſian* way of augmenting ice. But to proceed: Our having met with but an unſatisfactory account of this experiment, which we were the more troubled at, becauſe this ſeemed a promiſing way of trying that, which otherwiſe is not ſo eaſily reduced to experiment; for the temperature of the air muſt be ſeriouſly conſidered in aſſigning the cauſe of divers trials, that may be made for the reſolving of the ſame queſtion: For to omit other examples, here in *England* we find, that water poured on ſnow is wont

to haſten the diſſolution of it; and not to be congealed by it; whereas having inquired of an ingenious perſon, that lived a good while among the *Ruſſians*, he informed me, that it was their uſual way to turn water and ſnow into ice, by pouring a convenient proportion of that liquor into a great quantity of ſnow: and having alſo inquired, whether ice had not the like operation, he told me, that it was uſual, and he had ſeen it practiſed in *Muſcovy*, to cement ice to buildings, and other things, and alſo to caſe over bodies, as it were, with ice, by gradually throwing water upon them. But I doubt, whether that effect be to be aſcribed barely to the contiguity of the ice, becauſe I learned of him, that this way of increaſing ice is practiſed in very froſty weather, when water thinly ſpread upon almoſt any other body would be frozen by the vehement ſharpneſs of the air.

7. THE glaciations, that nature unguarded by art is wont to make, beginning at thoſe parts of bodies, at which they are expoſed to the air; it uſually happens, that they freeze from the upper towards the lower parts. But how far in earth and water (the moſt conſiderable bodies, that are ſubject to be frozen) the froſt will pierce downwards, though, for ſome hints it would afford, worth the knowing, is not eaſy to be deſined; becauſe the deepneſs of the froſt may be much varied by the degree of coldneſs in the air, by which the glaciation ſeems to be produced, as alſo by the greater or leſſer duration of the froſt, by the looſer or cloſer texture of the earth, by the nature of the juices, wherewith the earth is imbued, and by the conſtitution of the ſubjacent and more internal parts of the earth, ſome of which ſend up either actually warm, or potentially hot and reſolving ſteams, ſuch as thoſe, that make corroſive liquors in the bowels of the earth; ſo that the froſt will not ſeize upon, or at leaſt cannot continue over mines. And I have ſeen good large ſcopes of land, where vaſt quantities of good lime-ſtone lay near the ſurface of the earth, on which I have been aſſured by the inhabitants, that the ſnow will not lie. There are divers other things, that may vary the depth, to which the froſt can penetrate into the ground, (I ſay, into the ground, becauſe in moſt caſes it will pierce deeper into the water;) but yet, that we may not leave this part of the *Hiſtory of Cold* altogether uncontributed to, we will add ſome of our notes, whereby it will appear, that in our climate the froſt pierces far leſs into the ground, than many are pleaſed to think.

8. THE notes I find about this matter are theſe that follow, which I tranſcribed unaltered, becauſe it were tedious, and not worth while to add the way we imployed, and the cautions we uſed in making the obſervations; but we ſhall rather intimate, that the following trials were made in a village about two miles from a great city.

Jan. 22. [I. AFTER four nights of froſt, that was taken notice of for very hard, we went into an orchard, where the ground was level, and not covered with graſs, and found by digging, that the froſt had ſcarce pierced into the ground three inches and a half. And in a garden nearer the houſe, we found not the earth to be frozen more than two inches beneath its ſurface.

II. Nine or ten nights ſucceſſive froſt froze the graſsleſs ground in the garden, about ſix inches and a half, or better in depth, and the graſsleſs ground in the orchard, where a wall ſheltered it from the ſouth ſun, to the depth of about eight inches and a half, or better.]

Feb. 9. [WE digged in an orchard near a wall, that reſpects the north, and found the froſt to have pierced the ground about a foot and two inches, at leaſt above a foot: this is the eighth day ſince it was about eight inches and a half.]

[A ſlender pipe of glaſs, about 18 inches long, and ſealed at one end, was thruſt over night into a hole, purpoſely made with a ſpit ſtraight down into the ground, the ſurface of the water being in the ſame level with that of the earth; the next morning the tube being taken out, the water appeared frozen in the whole capacity of the cylinder, but a little more than three inches. But from this ſtick of ice, there reached downwards a part of a cylinder of ice of about ſix inches in length, the reſt of the water remained unfrozen, though it were an exceeding ſharp night, preceded by a conſtitution of the air, that had been very laſting, and very bitter. The earth in the garden, where this trial was made, we gueſſed to be frozen eight or ten inches deep, as it was in another place about the ſame houſe. But if this tube had not been in the ground, the ambient air would have frozen it quite through.]

9. ANOTHER note much of the ſame import, we find in another place of our collections.

FINDING, that by reaſon of the mildneſs of our climate, I was ſcarce to hope for any much deeper congelation of the earth or water, I applied myſelf to inquire of an ingenious man, that had been at *Moſco*, whether he had obſerved any thing there to my preſent purpoſe, as alſo to find in captain *James*'s voyage, whether that inquiſitive navigator had taken notice of any thing, that might inform me, how far the cold was able to freeze the earth or water in the iſland of *Charleton*, where that quality may probably be ſuppoſed to have had as large a ſphere of activity, as in almoſt any part of the habitable world. And by my inquiries I found, that even in frozen regions themſelves, a congealing degree of cold pierces nothing near ſo deep into the earth or ſea as one would imagine; for the traveller I ſpoke with, told me, that in a garden in *Moſco*, where he took notice of the thing I inquired about, he found not the ground to be frozen much above two foot deep. And in captain *James*'s journal, *page* 63. the moſt that I find (and that too, where he gives an account of the prodigiouſly tall ice they had in *January*) concerning the piercing of the froſt into the ground, is this, that *the ground at ten foot deep was frozen*. Whence by the way we may gather how much ſharper cold may be preſumed to have reigned in

in that iſland, than even in *Ruſſia*. And as for the freezing of the water, he does in another place occaſionally give us this memorable account of it, where he relates the manner of the breaking up the ice in the frozen ſea, that ſurrounds the iſland we have been ſpeaking of: 'It is firſt to be noted (ſays he, *page* 86.) 'that it doth not freeze (naturally) above ſix 'foot; the reſt is by accident; ſuch is that ice, 'that you may ſee here ſix fathom thick. This 'we had manifeſt proof of, by our digging the 'ice out of the ſhip, and by digging to our 'anchors before the ice broke up.' The reſt of that account not concerning our preſent purpoſe, I forbear to annex; only taking notice, that notwithſtanding our lately mentioned experiment of freezing water in a glaſs tube thruſt into the ground, yet it ſeems, that at leaſt where captain *James* wintered, the water was not much above half ſo thick frozen as the earth. But we have already noted the indiſpoſition of ſalt water to congelation; and whether freſh water would not have been deeper frozen, may be juſtly doubted.

TITLE XIV.

Experiments touching the differing Mediums, through which cold may be diffuſed.

1. IN examining whether cold might be diffuſed through all mediums indefinitely, notwithſtanding their compactneſs, or the cloſeneſs of their texture, we muſt have a care not to make our trials with mediums of too great thickneſs, leſt we miſtakingly impute that to the nature of the medium, which is indeed cauſed by the diſtance, which the medium puts betwixt the agent and the patient. For the mixtures of ice and ſnow, wherewith we made our experiment, will operate but at a very ſmall diſtance, though the medium reſiſt no more than the common air, as may appear by ſome of the experiments recorded in this treatiſe.

THIS premiſed, we may proceed to relate, that having placed a copious mixture of ice and ſalt in pipkins glazed within, and in white baſons glazed both within and without, we obſerved, that the outſide of both thoſe ſorts of veſſels was cruſted over with ice: though, however the baked earth had not been compact, nor the vitrified ſurface of a very cloſe texture; the very thickneſs of the veſſels was ſo great, that it ſeemed it would ſcarce have been able to freeze at a greater diſtance.

2. BY the experiments formerly mentioned of freezing water in pewter bottles, it appears, that cold is able to operate through ſuch metalline veſſels.

3. AND this may be ſomewhat confirmed by one of the prittieſt experiments, that is to be performed by the help of cold, namely, the making icy cups to drink in. The way we uſed was this; we cauſed to be made a cup of lattin (by which I mean iron reduced into tin plates, and tinned over on both ſides) of the ſhape and bigneſs I intended to have the cup of; then I cauſed to be made of the ſame matter another cup of the ſame ſhape with the former, but every way leſs; ſo that it would go into the greater, and leave a competent interval for water betwixt its convex ſurface, and the concave of the other. This innermoſt cup was furniſhed with a rim or lip, by which it leaned upon the greater, and by whoſe help its ſides and bottom were eaſily placed at a juſt and even diſtance from the ſides and bottom of the other; but the diſtance between the two bottoms is made greater, than that between the ſides, that the icy cup might ſtand the firmer, and laſt the longer. The interval between the two parts of this mould being filled with water, and the cavity of the internal cup being filled with a mixture of ice and ſalt, (partly to freeze the contiguous water, and thereby cooperate to the quicker making of the cup, and partly by its weight to keep the water from buoying up ſo light a cup;) the external part was ſurrounded with ice and ſalt, whoſe cold ſo powerfully penetrated to the internal metalline mould, that the water was quickly frozen, and (the parts of the mould being disjoined) appeared turned into an icy cup of the bigneſs and figure deſigned. And theſe cups being eaſily to be made, and of various ſhapes (and that in the midſt of ſummer, if ſnow or ice be at hand) are very pleaſant trifles, eſpecially in hot weather, when they impart a very refreſhing coolneſs to the drink poured into them; and though they laſt not long, eſpecially if they be employed to drink wine, and ſuch like ſpirituous drinks in, yet whilſt ſome are melting, others may be provided, and ſo the loſs may be eaſily repaired. All the difficulty we met with, was to disjoin the parts of the mould, which are wont to ſtick very faſt to the ice they include: and we tried to obviate this, ſometimes by anointing the inſide of the mould with ſome unctuous and not offenſive matter, to hinder the adheſion of the ice, and ſometimes by applying ſome convenient heat both to the convex part of the external, and the concave part of the internal piece of the mould; which laſt mentioned way is quick and ſure, but leſſens the durableneſs of the cup.

[WE were lately informed, that this way of making cups of ice, is ſet down in *Barcley's Argenis*, and it is like enough, that ingenious man may have learned it amongſt ſome of the virtuoſi of *Italy* he converſed with: but if we, that learned it from none of them, had not been taught it by experience, we ſhould ſcarce have ventured to try it upon the credit of a romance; that ſort of compoſures being wont to be fabulous enough to paſs but for poems in proſe.]

4. THE learned and induſtrious mathematician *Eraſmus Bartholinus* mentions in his newly-publiſhed diſcourſe *de Figurâ Nivis*, an experiment, by which he tells us, that ſome maſters of nature's ſecrets do eaſily, even in the midſt of heat, reduce water into air. For they put a little ſnow or ice into a funnel, and thereby ſo refrigerate and condenſe the ambient air, that there will dew trickle down the ſides of the funnel: by which means it has been ſaid, that ſome ingenious men have hoped

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to make an artificial fountain in the midſt of ſummer. But I here mention this experiment rather, becauſe it is not unlikely to pleaſe thoſe, to whom it is new, and becauſe having purpoſely tried it in large and thick funnels of glaſs, it may be pertinently enough delivered in this place, (where we are treating of the tranſmiſſion or propagation of cold through cloſe and thick mediums,) than becauſe we expect to make of it that uſe, eſpecially that oeconomical uſe, that has been lately intimated. For firſt, it will be very hard to prove, that it is the very air itſelf, and not rather the vapours ſwimming in it, that are by this means tranſmuted into water. And ſecondly, it is true indeed, that a mixture of ſnow and ſalt will condenſe vapours on the outſide of a funnel; but either they, that hoped to make this uſe of the experiment, have little experience of it, and write conjecturally, or elſe they have made it with a ſucceſs very differing from ours. For though we employed a large funnel, and ſuſpended it by a ſtring (artificially enough tied about it) in the free air; and though the mixture of ice and ſalt we put in, were ſufficiently infrigidating (as will appear by and by) and far more ſo, than ice or ſnow alone would have been; yet that mixture being not able to condenſe the vaporous parts of the air into dew, much, if at all, longer than the mutual diſſolution of the ſalt and ſnow laſted, the liquor, that was this way obtained, and dropped down at the bottom of the funnel (whoſe internal perforation ought to be carefully ſtopped, leſt any of the reſolved ſnow and ſalt ſhould fall through, and ſpoil the other liquor) was indeed ſweet like rain-water, but ſo very little, as well as ſo ſlowly generated, that it amounted not any thing near to that, which the ſnow imployed, and ſpoiled to make it, would have afforded. So that it may be queſtioned, whether ſome cooling liquors, which can as well as this mixture condenſe the vapid air into water, and whoſe texture is not deſtroyed in this operation, as that of the ſnow is, might not be more hopefully imployed to obtain water from the air; to which I ſhall only add this one thing, that the mixture of ſnow and ſalt did turn the vapours, that faſten themſelves to the outſide of the glaſs, firſt into ice, before they drop down in the form of water, in almoſt all our trials of this nature, as well in thick funnels, as in other, and thinner glaſſes.

5. THAT in hermetically ſealed glaſſes, an included mixture of ſnow and ſalt will freeze the vapours of the air on the outſide of the glaſs, divers of the experiments of the preſent treatiſe do manifeſtly evince; which argue, that even ſo extremely cloſe a medium as glaſſes is not able to hinder the tranſmiſſion of cold. And this is not ſuperfluouſly added, becauſe in veſſels not hermetically ſealed, it may be pretended, that it is the internal air, that communicates its coldneſs by ſome unheeded, but immediate intercourſe, with the external.

AFTER this we thought it worth an experiment, to try, whether, or how, cold would be diffuſed through a medium, that ſome would think a vacuum, and which to others would ſeem much leſs diſpoſed to aſſiſt the diffuſion of cold, than common air itſelf. To compaſs this, the expedient we bethought ourſelves of, was to ſuſpend a ſlender glaſs full of water in one of the ſmall receivers belonging to our pneumatical engine; and when the air was very carefully pumped out, to bury the exhauſted receiver in a copious and ready prepared mixture of ice and ſalt, to ſee whether, notwithſtanding the withdrawing of the medium, the water ſuſpended in a kind of vacuum, as to air or groſs ſubſtances, would yet be frozen by the cold. That event of our trials, which alone I find among my notes, is regiſtered in theſe terms.

6. [A SMALL pipe, ſealed at one end, was, at the other, filled almoſt with water, and was put into a receiver, conſiſting of a ſomewhat long and ſlender tube of glaſs, ſealed at one end, and inverted upon the engine plate; then the air was carefully exhauſted, for the pump was plied; a while after no air appeared to come forth in any bubble out of the receiver, through the external water; nor did the water in the ſmall pipe within diſcloſe any number of bubbles worth taking notice of: then by the help of an almoſt cylindrical plate of iron, beaten ice and ſalt were heaped againſt the outſide of the receiver, about the height, to which the water in the ſmall pipe reached. And at length, though, as we all thought, much more ſlowly than ſuch a congelation would elſe have been performed, the water was for the moſt part frozen in odd kind of flakes from the top to the bottom, and the ice ſeemed not to have any conſiderable number of bubbles.]

7. THERE is one experiment, I have made about the tranſmiſſion of cold through indiſpoſed mediums, which may not be unworthy to be here inſerted. For I had once a mind to try, whether a cold body could operate through a medium, that was, as to touch, actually hot, and had its heat continually renewed by a fountain, as it were, of heat, that perpetually diffuſed through it new ſupplies of warm liquor; ſo that the cold body could not here, as in other caſes, firſt allay the heat of the medium, and then leſſen it more and more, till it had quite extinguiſhed it. To compaſs this, I had ſoon after an opportunity of making ſome trials preſented me: for being at the mineral ſprings at *Tunbridge*, to drink thoſe wholeſome waters for my health's ſake, I ſoon accuſtomed myſelf to drink them in conſiderable quantities very early in the morning, when they were exceeding cold, and ſometimes drinking them in bed, as well as ſometimes at the ſpring's-head, I had the curioſity to obſerve, whether, in caſe I took them down very faſt, they would not through the warm muſcles and outward parts of the abdomen, diffuſe a ſenſible coldneſs: and upon more trials than one, I found, that by laying my warm hands on the outſide of my belly, I there felt, at leaſt as it ſeemed to me, a manifeſt and conſiderable degree of coldneſs. And when I related this to ſome ingenious

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perſons, that were better acquainted with thoſe ſprings than I, they told me, that there was among thoſe many, that then reſorted to thoſe famous ſprings, a knight, whoſe name I remember not, whoſe diſeaſe being judged formidable, the phyſicians enjoined him to drink in a morning two or three times the quantity, that afforded me the obſervation I was relating; and that when this knight had filled his belly with ſo much water, he uſed mightily to complain of the coldneſs it diffuſed through his abdomen, inſomuch that he was fain to ply thoſe parts long with hot napkins clapped to them, one after another; which yet, as he complained, were ſoon refrigerated by the exceſſive cold, that the water diffuſed to the outſide of his belly; which yet nevertheleſs was not, that I could learn, at all prejudiced, no more than mine, by ſo ſenſible and piercing a cold.

8. IT may be doubted, whether in caſe water be not fluid upon the account of a congenite motion in the corpuſcles it conſiſts of, its fluidneſs may not proceed from the agitation of the ambient air, either immediately contiguous to the ſurface, or communicating its agitation to the water, by propagation of its impulſe, through the veſſel, that interpoſes betwixt them. To contribute to the clearing of this, and ſome other things, we deviſed the following experiment: We provided a glaſs-bubble, of about the bigneſs of a walnut, and the form almoſt of a pear, whoſe ſtem was purpoſely made crooked for the conveniency of ſuſpenſion. This being filled with water (which is troubleſome enough to be done, unleſs one have the knack) we hung it at one end of a thread, whoſe other end we paſt through a cork, by a perforation purpoſely made; into which we afterwards faſtened a thread, by thruſting in a ſmall peg to rivet it in. Then filling a glaſs not very broad, but yet furniſhed with a mouth wide enough to receive the bubble, with oil of turpentine, ſuch as we bought it at the ſhops, we ſtopped the orifice with the newly mentioned cork; ſo that the ſealed bubble hanging at it was covered, and every way ſurrounded by the oil of turpentine; which being a liquor, that (at leaſt in ſome colds as we here have) will not freeze, we placed the glaſs in beaten ice and ſalt, and as it were buried it therein: and at the end of about three hours (having been diverted by ſome occaſions from taking it ſooner out) we found, as we had conjectured, that, notwithſtanding that, the oil of turpentine continued perfectly fluid as before, yet the bubble totally immerſed in this heating chymical oil was frozen throughout, not excepting that, which was harboured in the little neck or ſtalk; and when I came to lift it out of the liquor, the glaſs being cracked (as we ſuppoſed by the cold) the ſtring brought up a little part of that, which was neareſt to it; the reſt in the form above mentioned ſtaying behind and ſubſiding. And that, which was remarkable in this piece of ice, was, that when we had taken it out, it appeared cleft very deep (from the outſide almoſt to the centre) according to a line drawn from the ſlendereſt part of it, almoſt as if one ſhould with a knife cut a pear in two, from the ſtalk downwards, according to its whole length. And theſe two pieces were eaſily enough ſeparable, and (to add that circumſtance) for trial ſake we left them divided in the ſame liquor and veſſel, with ſome thawing ice and ſalt about them, for 14 or 15 hours, without finding them any thing near ſo much waſted or reſolved into water, as moſt would have expected.

WHILST the above mentioned veſſel was expoſed to be frozen, we likewiſe placed by it another veſſel, a glaſs-egg, whoſe ball and a little part of its ſtem we had filled with ſome of the very ſame parcel of oil of turpentine; and placing about the ſides of the egg ſome ice and ſalt, we obſerved, as we expected, that the liquor was, after a little while, made by the cold to ſubſide about half an inch: ſo that it is worth ſome philoſophers conſidering, why, if according to the lately mentioned atomical doctrine, cold be made by the introduction of ſwarms of real and extended, though atomical bodies, they ſhould pervade the oil, and contract it without freezing it, but freeze the water without contracting it, but expanding it rather.

9. [A SMALL bubble of the bigneſs of a very little nutmeg, filled with water, and hermetically ſealed up, was by a cork and a ſtring ſuſpended in ſpirit of wine, ſo as to be ſurrounded therewith; and being expoſed to the air the ſame night, in the ſtopt glaſs, was the next morning found altogether frozen, though the ſpirit of wine it ſelf were not at all ſo: but another bubble, by the help of a ſtring cork, and piece of lead, carefully ſuſpended in a ſtrong ſolution of ſea-ſalt, and expoſed at the ſame time in a like veſſel with the former, when they both came to be looked upon, appeared to be no more frozen than the brine it ſelf, which was not ſo at all.]

10. [A GLASS bubble of the bigneſs of a ſmall nutmeg, filled with water, and hermetically ſealed, being immerſed by a weight of lead faſtened to it, beneath the ſurface of a very ſalt brine, but yet not ſo as to reach the bottom of the liquor or glaſs, was expoſed all night to freeze, in weather, that was extraordinarily cold; but neither the impriſoned water, nor the other appeared to be at all frozen. The like experiment we repeated another froſty night, but without freezing either of the liquors. But to ſhew the uſefulneſs of repeating experiments about cold, if there be opportunity, and eſpecially in ſuch caſes, where the degree or ſome other circumſtance may much vary the event, we will add, that having expoſed a bubble like that newly mentioned, and immerſed in ſpirit of wine, we found the next morning the water in the bubble turned into ice; and having likewiſe expoſed ſuch a bubble immerſed in very ſtrong brine, to be frozen by a mixture of ice and ſalt, within about two hours after, we found the bubble broken, as we ſuppoſed, upon the expanſion of the water upon its growing ice. And we alſo found the upper part of the bubble with the ice ſticking to it, and the other part of the glaſs

was

was cracked, with lines running from a point almoſt like the pole and meridian in a globe; whence we concluded the glaſs to have been, as it is probable, burſt aſunder upon the expanſion of the freſh water into ice; and that the reaſon, why there remained but a comparatively little parcel of ice, was probably, that the ſalt water getting in at thoſe crannies or chinks, diſſolved as much of the new-made ice, as in a little while it could eaſily reach.

Beſides;

11. [We filled a glaſs bubble with fair water, and having hermetically ſealed it, we ſuſpended it by a ſtring faſtened to the cork in the cavity of a wide-mouthed glaſs well ſtopt, ſo that the bubble was every way at a good diſtance from the ſides, bottom, and top of the glaſs. This we did to try, whether a ſufficient degree of cold at that diſtance would be freely tranſmitted through the glaſs, without the intervention of a viſible liquor; and accordingly we found the ſuſpended bubble cracked by the ice, that filled it.]

TITLE XV.

Experiments and obſervations touching ice.

1. A GREAT part of our preſent hiſtory being imployed about delivering the phænomena of congelation, it is not to be expected, that in this ſection, where we treat of ice as a diſtinct part of our theme, we ſhould deliver all thoſe particulars, that have occurred to us, wherein ice is concerned. And therefore we ſhall reſtrain our ſelves to the mention of thoſe, that belong to ice, conſidered, as it conſiſts of intire and diſtinct portions of congealed water. And though we ſhall deliver ſome few experiments of our own, ſuch as we had any opportunity to make, yet much the greater part of this ſection will fitly enough be taken up by collections out of travellers, and navigators, into thoſe colder regions, that afford much conſiderabler, or at leaſt much ſtranger obſervations concerning ice, than are to be met with in ſo temperate a climate as ours. And what we have to deliver in this ſection will naturally be divided into two parts, the one conſiſting of our own experiments, and the other containing ſome paſſages, that we have ſelected out of voyages, or that have been afforded us by the relations of credible travellers. And of theſe two ſorts of obſervables, that, which has been firſt mentioned, ſhall be firſt treated of.

2. Some, that have been in the *Eaſt-Indies*, inform us, that in ſome parts of thoſe countries they were looked upon as great lyars, for affirming, that in *Europe* the fluid body of water was often without any artifice or endeavour of man turned in a few hours into a ſolid and compact body, ſuch as ice. And certainly, if cuſtom did not take away the ſtrangeneſs of it, it would to us alſo appear wery wonderful, that ſo great a change of texture ſhould be ſo eaſily and inartificially produced. But how ſolid the body of ice is, or rather how ſtrong is the mutual adheſion of its parts, has not yet, that we know of, been attempted by experiments to be reduced to ſome kind of eſtimate: and indeed ſo many things muſt be taken into conſideration, that it will be difficult to arrive at any more than a fair conjecture in this matter; eſpecially, becauſe (I think) it may juſtly be doubted, whether or no differing degrees of cold may not vary the degree of compactneſs of the ice. And my doubt will not perhaps appear groundleſs, if I add, that having, to ſatisfy my ſelf, inquired of an intelligent perſon, that lived ſome years in *Ruſſia*, he anſwered me, that he found the ice of thoſe parts to be much harder than that of theſe.

3. We had in our thoughts divers ways to eſtimate the coheſion of the parts of ice, whereof one was, to freeze water in a hollow metalline cylinder, and taking out the ice, and keeping it in a perpendicular poſture, caſt into a ſcale weighed beforehand, and carefully faſtened to the bottom of the ice, more and more weight, till the mere weight broke the cylinder: and this we had thoughts to try in cylinders of differing diameters and lengths, but wanted conveniencies to make the experiments; (which if they were made, as ſome of our trials were, in the open air, and in places expoſed to ſome gelid wind, it would the better ſecure the ice from being weakened or thawed during the trials.)

4. We therefore attempted, by another way, to inveſtigate the ſtrength of ice. For we took a plate of it, of an uniform, and alſo of a conſiderable thickneſs, and with ſides cut parallel, that it might ſerve for a kind of leaver, and placed it betwixt two wooden bars, whoſe diſtance we knew; and then laying on it a great weight, the centre of whoſe preſſion, as near as we could eſtimate, was equally, or in determinate meaſures, diſtant from the wooden fulcrums, we endeavoured to try, how great a weight it would ſupport; but in the village, where we made the trials, we could not get weights, that were conveniently ſhaped, and ponderous enough, to break it; and though we cauſed a man to ſtand upon it, yet neither could his weight break it; till he chanced to add an impreſſed force with his foot to the weight of his body. So that being unable to determine, what that additional and impreſſed force might amount to, almoſt all that we could ſafely conclude, either from this experiment, or ſome other ways of trial with ſcales, and other ways, that we made uſe of, (but for want of conveniencies unſucceſsfully) was, that the force of ice to ſupport weights is much greater than men can imagine; which ſeems ſomewhat the more ſtrange, becauſe it is not here in *England* ſo ſolid a body, as by this one would gueſs: for not only glaſs would readily ſcratch it deep enough, but even with common knives we could cut it, and that with great eaſe.

5. Yet one not inconſiderable account I was able to give my ſelf of the ſtrength of ice, which I find in my notes thus delivered.

[There was taken a piece of ice three inches long, and three broad, and ſomewhat leſs than a quarter of an inch thick; this was laid croſs-ways

croſs-ways upon a frame, ſo that the two parts, on which the ice leaned, were diſtant three inches: then there was taken an iron, ſhaped like the figure of (the common arithmetical cipher, that denotes ſeven) 7, to whoſe hanging leg, if I may ſo call it, there was faſtened at the end, which was under the middle of the ice, a ſcale, into which ſeveral weights were put, ſuch as by ſome former trials we gueſſed to be almoſt as much as the ice would well ſuffer: after which, the horizontal leg of the iron was very gently laid upon the ice, as near as we could gueſs, in the middle of the diſtance, between the two ſides of the frame, and conſequently parallel to them both. Then the weights not proving altogether ſufficient to break the ice, we let them hang a while at it, and obſerved, how the edge of the incumbent leg of iron (which edge was * broad) did work it ſelf downwards into the ice; ſo that by our gueſs, when the ice broke, as after a while it did, it had loſt at one end of the inciſion, if I may ſo call it, half its thickneſs, and at the other, about a third part of it.

THE weights, that broke it, amounted to 17 pounds averdupois, and 117 ounces Troy.

6. THE experiment was repeated with all the former circumſtances, only the piece of ice was two inches and a half broad, and a quarter of an inch thick, and the diſtance of the frame was three inches, as before; the weights, that broke it, were 17 pounds averdupois, and 41 ounces Troy. The horizontal arm of the iron had melted ſomewhat more than half through the ice when it broke, *viz.* more than $\frac{2}{3}$ of the thickneſs at one end, and ſomewhat leſs than half at the other.

7. WE divers times intimated in ſome of the firſt ſections of our preſent hiſtory, that the addition of ſalt to ice did haſten the diſſolution of it, which though it may be eaſily proved by ſome other phænomena of our experiments, yet it will not be amiſs to mention here a couple of particular trials, by which we have more manifeſtly evinced it. And firſt, we divers times took a broad and flat plate of ice, leſs than a quarter of an inch thick, and having placed it horizontally upon a joint-ſtool, (a table, or any other flat piece of wood will do as well) we ſtrewed here and there a convenient quantity of bay-ſalt upon it; and though we obſerved, that, if the ſurfaces of the ice and ſtool were not both of them flat, and congruous enough, the ice would be thawed indeed, but the other part of the experiment would not well ſucceed; yet when we made the trial carefully and watchfully, the plate of ice partly thawed by the ſalt would be ſo firmly frozen to the ſtool it leaned on, that we were fain with an iron inſtrument to knock it all to pieces, before we could ſever it from the ſtool; into whoſe pores the ice newly generated by the experiment did pierce ſo deep, that, notwithſtanding our knocking, many little parcels of ice would continue to ſtick cloſe to the wood, whoſe pores they had invaded. But the circumſtances, which in this experiment made the moſt to our purpoſe, are theſe two; the one, that having ſometimes laid the ſalt but on few, and ſomewhat diſtant parts of the plate, the intermediate parts would many of them remain unfrozen to the ſtool; whilſt thoſe, where the ſalt had been laid, were frozen ſo hard to it. And the other circumſtance is, that the groſſer grains of ſalt would ſo far diſſolve the ice, whereto they were contiguous, as (if I may ſo ſpeak) to bury themſelves therein; whilſt the other parts of the ice, upon which, or near which, no ſalt had been laid, kept their ſurfaces ſmooth and intire. We tried likewiſe two or three times to freeze a plate of ice to a flat piece of wood, by making uſe of aqua fortis, inſtead of common ſalt; but the experiment ſucceeded not well, though once we brought the ice to ſtick to the wood manifeſtly, but not ſtrongly.

8. TO this we ſhall add the following experiment, which, when we watchfully made it, ſucceeded well, and I find it among my notes ſet down in theſe terms.

[SOLID fragments of ice having pretty ſtore of ſalt thrown on them, upon the firſt falling of the ſalt among the ice there was produced a little crackling noiſe, and for a good while after there manifeſtly aſcended out of ſeveral parts of the mixture, conveniently held betwixt a candle and the eye, a ſteam or ſmoke, like that of warm meat, though the night were rainy and warm, and though the morning had not been froſty.]

The mention here made of the crackling noiſe made by the ice upon the addition of ſalt, (which ſeemed to proceed from the crackling of the brittle ice, produced by the operation of the ſalt upon it) brings into my mind an experiment I had formerly made, whereof a greater noiſe of the ſame kind is a phænomenon, though the experiment were chiefly made for the diſcovery of the texture of ice: the event of the trial I find thus ſet down among my notes.

9. [WE took ſome cakes of ice, each of the thickneſs between $\frac{1}{8}$ and $\frac{1}{4}$ part of an inch, but not ſo very compact ice, as to be free from ſtore of bubbles: ſome good aqua fortis dropped upon this did quickly penetrate it with a noiſe, that ſeemed to be the cracking of the ice, underneath which the ſour liquor was plainly to be taſted. Oil of vitrol did the ſame, but much more powerfully, and without ſeeming to crack the ice, which it paſt through; ſo that though but three or four drops were let fall upon the plate, it immediately ſhewed it ſelf in drops exceedingly corroſive on the other ſide of the ice. And the like ſucceſs we had with a trial made with the ſame liquor, upon three ſuch plates of ice frozen one upon the top of another.]

10. HAVING proceeded as far as we were able towards the bringing the ſtrength of ice to ſome kind of eſtimate, by ſuch experiments as we had opportunity to make here, we thought it not amiſs to ſeek what information we

* The breadth was, I know not how, omitted in the note; but, as I remember, it was about an 8th part of an inch.

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we could get about this matter among the deſcriptions, that are given us of cold regions: but I have not yet found any thing to have been taken notice of to this purpoſe worth tranſcribing, except a paſſage in the archbiſhop of *Upſal*, wherein, though the eſtimate of the force of ice be, as we ſhall by and by ſhew, made after a groſs manner, yet ſince this it ſelf is more than I have met with elſewhere, I think it worth ſubjoining, as our author delivers it in theſe terms: *Glacies* (ſays he) *primæ & mediæ hyemis adeò fortis & tenax eſt, ut ſpiſſitudine ſeu denſitate duorum digitorum ſufferat hominem ambulantem, trium vero digitorum equeſtrem armatum; unius palmæ & dimidiæ, turmas, vel exercitus militares; trium vel quatuor palmarum integram legionem ſeu myriadem populorum, quemadmodum inferiùs de bellis hyemalibus memorandum erit.*

Olaus Ma. Gent. Septentr. Hiſt. l. 1. c. 14.

But though this be ſufficient to afford us an illuſtrious teſtimony of the wonderful ſtrong coheſion of the parts of ice, yet we mentioned it but as a popular way of eſtimate, which may better embolden travellers, than ſatisfy philoſophers, in regard, that the author determines only the thickneſs of the ice, and not the diſtance of that part of it, that ſupports the weight from the ſhore or brink, on which, as on a hypomoclion, the remoteſt part of the ice does lean or reſt. And if we conſider the ice as a lever, and the brink or brinks, on which it is ſupported, as a ſingle or double fulcrum, the diſtance of the weight may be of very great moment in reference to its preſſure or gravitation on the ice, which may more eaſily ſupport the weight of divers men placed very near the prop, than that of one man placed at a great diſtance from it; as will be eaſily granted by thoſe, that are not ſtrangers to the mechanicks, eſpecially to the nature and properties of ſeveral kinds of levers. But not now to debate, whether in certain caſes, the ice we ſpeak of, may not receive ſome ſupport from the ſubjacent water, nor whether ſome other circumſtances may not ſometimes be able to alter the caſe a little, our very conſidering the ice as a ſingle or double lever, though it may hinder us from meaſuring the determinate ſtrength of ice upon *Olaus*'s obſervation, yet it will ſet forth the ſtrength of it ſo much the more, ſince by his indefinite expreſſions he ſeems ſufficiently to intimate, that when the ice has attained ſuch a thickneſs, its reſiſtance is equivalent to ſuch a weight, without examining on what part of the ice it chances to be placed.

II. Thus far our experiments concerning ice, with the appendix ſubjoined out of *Olaus* to the ſame purpoſe. We will now proceed to ſome of the obſervations we have met with in ſeamen's journals, and elſewhere. I ſay to ſome, becauſe to enumerate them all, would ſpend more time and labour than I can afford; and therefore I ſhall reſtrain myſelf to the mention of ſome few of the chiefeſt.

I. And in the firſt place for confirmation of what I delivered, at the beginning of this ſection, from the report of a traveller into *Ruſſia*, touching the hardneſs of ice in thoſe gelid climates, in compariſon of our ice, which I have found it eaſy to ſcrape with glaſs, or to cut with a knife; I ſhall ſubjoin this paſſage of Captain *G. Weymouth*, in his voyage for the the diſcovery of the North-weſt paſſage: 'As we were (ſays he) breaking off ſome of this ice, which was very painful for us to do, for it was almoſt as hard as a rock, &c.' Purchas. *Lib.* 4. *Chap.* 13.

II. Next to ſhew, that it was not a ſuperfluous warineſs, that made me in a former ſection doubt, that even the ice made of ſea-water might be altogether or almoſt inſipid; I will ſubjoin, that I have ſince met with ſome relations, that ſeem to juſtify what is there delivered. And in one of our Engliſhmen's voyages into the Northern ſeas, I find more than one inſtance to my preſent purpoſe, though I ſhall here ſet down but one, which is ſo full and expreſs, that it needs no companions; our navigator ſpeaking thus; 'About nine of the clock in the forenoon, we came by a great iſland of ice, and by this iſland we found ſome pieces of ice broken off from the ſaid iſland; and being in great want of freſh water, we hoiſted out our boats of both ſhips, and loaded them twice with ice, which made us very good freſh water.' Purchas. *Lib.* 4. *cap.* 13. *pag.* 813.

But all this notwithſtanding, I yet retain ſome ſcruple, till thoſe, that have better opportunity to make a more ſatisfactory experiment, ſhall eaſe me of it. For though by theſe narratives it ſeems more than probable, that the ice in the midſt of the ſea conſiſts but of the freſh particles of water, that plentifully concur to compoſe the ſea water; yet beſides that, in caſe the freſh water were taken, as ſome of that I have found mentioned in voyages, has confeſſedly been, from the top of the ice, it might poſſibly be no more than melted ſnow, which, as we elſewhere take notice, does in thoſe extreme cold regions eaſily freeze upon the ice it falls on, and oftentimes much increaſes the height of it: beſides this, I ſay, the argument from the inſipidneſs of the reſolved ice will conclude but upon ſuppoſition, that as that ice was found in the ſea, ſo it was alſo made of the ſea water; which though it may have been, yet I ſomewhat doubt, whether it were or no, ſince I find ſome navigators of the moſt converſant in the cold climates to inform us, that moſt of thoſe vaſt quantities of ice, that are to be met with about *Nova Zembla*, and the ſtrait of *Weigats*, and that choak up ſome other paſſages, whereby men have attempted to paſs into the ſouth ſea, are compoſed of the accumulation of numerous pieces of ice (cemented by intercepted, and then frozen, water) that are brought down from the great river *Oby*, and others; ſo that it may very well be ſuppoſed, that theſe *mountainous

* Neither hereafter will I marvel, though the ſtrait of *Weigats* be ſtopped up to the North-eaſt, with ſuch huge mountains of ice, ſince the rivers *Oby* and *Jeneſce*, and very many more, whoſe names are not yet known, pour out ſuch a quantity thereof, that in a manner it is incredible: for it cometh to paſs in the beginning of the ſpring, that

tainous pieces of ice may be ſome of thoſe, which, upon the ſhattering of ice in bays and ſtraits, partly by the heat of the ſun, and partly by the tides, may be afterwards by the winds and currents driven all up and down the ſeas, to parts very diſtant from the ſhore; and ſome of theſe, it may be, that our countrymen met with, and obtained their freſh water from: which I the rather incline to think, becauſe that (as we ſhall have occaſion to obſerve in another ſection) the main ſea it ſelf is ſeldom or never frozen. But my ſcope in all this is but to propoſe a ſcruple, not an opinion.

III. The next and principal thing concerning ice is the bigneſs of it, which I find, by the relations partly of ſome acquaintances of my own, and partly of ſome navigators into the North, to be ſometimes, not only prodigious, but now and then ſcarce credible. And therefore, as I ſhall mention but few inſtances, that I have ſelected out of the beſt journals, and other writings I have met with, ſo I ſhall add a few more teſtimonies to keep them, by their mutual ſupport, from being entertained with a diſbelief, which their ſtrangeneſs would elſe tempt men to.

OF the vaſtneſs of ſingle mountains of ice, the moſt ſtupendous example, that, for aught I know, is to be met with in any language but ours, is that, which I formerly took notice of, out of the Dutch voyage to *Nova Zembla*, which was ninety-ſix foot high (that is, above twenty foot higher, than on a certain occaſion I found the leads of *Weſtminſter* Abbey to be.) But it is probable, that our Captain *James* met with as great, if not greater: for though in ſome places he mentions divers hills of ice, that were aground in 40 fathom water, and conſequently were as deep under water, as that newly taken notice of out of the Hollanders, *page* 14: and though he elſewhere mentions other pieces of no leſs depth, and twice as high as his top-maſt head, and this in *June*: yet elſewhere, and long after, relating his return home, he has this paſſage; *page* 106. 'We have ſailed through much mountainous ice, 'far higher than our top-maſt head: but this 'day we ſailed by the higheſt I ever yet 'ſaw, which was incredible indeed to be re-'lated.'

BUT the ſtupendouſeſt piece (for height and depth) of ſingle ice, that perhaps has been ever obſerved and meaſured by men, is that, which our famous Engliſh ſeaman Mr. *W. Baffin* (whoſe name is to be met with in many modern maps and globes) mentions himſelf to have met with upon the coaſt of *Greenland*, whoſe whole relation I ſhall therefore ſubjoin, not only becauſe of the ſtupendouſneſs of this piece of ice, but becauſe he takes notice of an obſervation, which I knew not to have been made by any, and comes ſomewhat near the eſtimate we formerly made of the proportion betwixt the extant and immerſed parts of floating ice; only the following eſtimate makes the extant part ſomewhat greater than we did; which may eaſily proceed from other men's having, as Mr. *Baffin* here does, grounded their computation upon what occurred to them at ſea, or in ſalt water, where the ice muſt ſink leſs than in freſh water, ſuch as my eſtimate ſuppoſed. Our navigator's words then are theſe: 'The 17th of *May* we ſailed 'by many great iſlands of ice, ſome of which 'were above 200 foot high above water, as 'I proved by one ſhortly after, which I found 'to be 240 foot high; and if the report of 'ſome men be true, which affirms, that there 'is but one ſeventh part of ice above water, 'then the height of that piece of ice, which 'I obſerved, was one hundred and forty fa-'thoms, or one thouſand ſix hundred and 'eighty foot from the top to the bottom. 'This proportion I know doth hold in much 'ice; but whether it do ſo in all, I know 'not.' Purchas, *lib.* 4. *cap.* 18. *pag.* 837.

THUS far of the height and depth of ſingle pieces of ice: as for the other dimenſions (the length and breadth) I remember not, that I have read of any, that had the curioſity to meaſure the extent of any of them, excepting Captain *James*; whoſe ſhip being once arreſted between ſome flat and extraordinary large pieces of ice, he and his men went out to walk upon them, and he took the pains to meaſure ſome of the pieces, which he ſays he found to be 1000 of his paces long, *pag.* 17. And probably among ſo many mountains and iſlands of ice, there would have been found ſome intire pieces, of a greater extent than even theſe, if men had had the curioſity to meaſure them.

HITHERTO we have treated of the bigneſs of ſingle pieces of ice; we will now proceed to ſay ſomething of the dimenſions of the aggregates of many of them, among which having elected four or five as the principal I remember myſelf to have yet met with, I preſume it will be ſufficient to ſubjoin them only.

'ABOUT ten of the clock we met with a 'mighty bank of ice, being, by ſuppoſition, 'ſeven or eight leagues, or twenty-four miles 'long,' ſays that experienced Engliſh pilot *James Hall*, in his voyage of *Denmark* for the diſcovery of *Greenland*.

ANOTHER of our Engliſh navigators mentions, that even in *June*, 'all the ſea (where-'in he was endeavouring to ſail) as far 'as he could ſee from the top of a high hill, 'was covered with ice; ſaving that, within a 'quarter of a mile of the ſhore, it was clear 'round about once in a tide.' By which laſt clauſe, it ſeems, that this vaſt extent of ice was either one entire floating iſland, or at leaſt a vaſt bank or rand (as ſome ſeamen term it) of ice.

BUT the ſtrangeſt account of banks of ice, that I have yet met with in any ſober author, is,

that in places near unto the ſea, the ice, through the exceſſive thickneſs, and multitude thereof, doth carry down wood before it. And without doubt this is the cauſe, that about the ſhore of the ſtrait of *Weigats*, ſo great abundance of floating wood is every where ſeen: and whereas in that ſtrait near unto *Nova Zembla*, it is ſo extreme cold, it is no marvel, if in regard of the narrowneſs of the ſtrait, ſo huge heaps of ice are gathered and frozen together, that in the end they grow to ſixty or at leaſt to fifty fathoms thickneſs: ſays the Deſcription of the countries of *Siberia*, *Samojeda*, &c. extant in *Purchas*'s third part of his Pilgrim. *Lib.* 3. *Chap.* 7.

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is, that which is mentioned by the learned French hydrographer, *Fournier*; who relates, that in the year 1635, the French fleet ſailing to *Canada*, met with ſeveral pieces of ice, as high as ſteeples, and particularly one, whether piece or bank of ice (for the French word *glace* may ſignify either) which they were troubled to coaſt along for above forty leagues. If this be the ſame ſtory, (as one may ſuſpect it to be, by the circumſtances of the place, and fleet,) there is a great miſtake in another place, where our author ſpeaks of the vaſtneſs of the ice: but if it be another ſtory, as ſome other differing circumſtances argue, the French, it ſeems, met with ice far more ſtupendous, than even that already mentioned. For, (ſays our author) in the ſea, which waſhes *Canada*, there is often ſeen in the month of *Auguſt*, to paſs by, ices much bigger than ſhips. In the year 1635, the French fleet ſailing there, coaſted along, for three days and three nights, one, that was above 80 leagues long, flat in ſome places like vaſt champions, and high in other like frightful hills. The latter part of which paſſage may confirm what we formerly delivered in another ſection, concerning the unequal compagination of icy iſlands.

Hydographie du P. G. Fournier, liv. 9. cap. 29. *compared with the 12th chapter of the ſame book.*

To what has been ſaid touching the extent, and other dimenſions of floating, or at leaſt looſe pieces of ice, it will be fit to add ſomething of the extent of ice, coherent to one or both of thoſe ſhores, that bound the water, whoſe upper part is congealed. And in the firſt place, we ſhall, out of many inſtances to our preſent purpoſe, that might be borrowed from the writings of *Olaus Magnus*, ſelect this one memorable one, that ſhall ſerve for all: *Neque minori bellandi impetu* (ſays he) *Sueci ac Gothi ſuper aperta glacie, quam in ipſa ſolidiſſima terra confligunt; imo, ut prius dictum eſt, ubi antea æſtivo tempore acerrima commiſſa ſunt bella navalia, eiſdem in locis glacie concreta, aciebus militari modo inſtructis, bombardis ordinatis, habentur horrendi conflictus. Adeo ſolida glacies eſt in equeſtribus turmis ſufferendis, ampliter vel ſtrictè collocatis.* I pretermit then, what he elſewhere relates of the voyages and wars made in winter by the Northern nations. They, that have lived in thoſe countries, relate, as things moſt known and familiar, (what has been confirmed to me by more than one unſuſpected eye-witneſs) the long journeys, that are commonly taken upon the icy bridges, or rather plains, by travellers, with all their carriages, to very diſtant places. And that, which may bring credit to theſe ſtrange relations, by ſhewing, that no leſs unlikely ones are ſometimes true, is, what all *Europe* knows, that within theſe three years the whole Swediſh army, led on by their king, marched over the ſea to the iſland of *Zeeland*, where *Copenhagen*, the capital city of *Denmark* ſtands *. But it may ſeem much more ſtrange, which I will therefore add, that as in the North countries frequently, ſo ſometimes even in the warmer regions of the Eaſt, the ſea itſelf has, by the cold, been congealed to a prodigious breadth. *Olai Mag.* lib. 3. cap. 2. pag. 334.

Inſolitum eſt, (ſaith *Bartholinus*) *quod refert Constantinus Manaſſes in Annalibus accidiſſe, Theophilo imperante, ut hyems ſæva mare cogeret in glaciem ad profunditatem ſanè immenſam, humidúmque illud elementum, lapidis ad duritiem, fluxione prorſus ademptâ, redigeret.* And *Michael Glycas* relates, 'That in the year 775, 'the winter was ſo ſharp in the Eaſt, that 'along the coaſt, the ſea (he means the Mediterranean) was frozen for 50 leagues, and 'the ice was compacted as into a rock, 30 cubits deep; ſo ſtrange a quantity of ſnow 'likewiſe falling, that it was raiſed to the 'height of 30 cubits above the ice.' Which likewiſe agrees very well with what we formerly noted, touching the poſſible increaſe of the height of ſome pieces of ice by the falling of the ſnow upon them. *Bartol. de nivis uſu.* cap. 6. *Glycas apud Fournier*, liv. 9. cap. 19.

IV. It remains now, that we ſubjoin a few promiſcuous obſervations concerning ice, that are not ſo readily deducible to the three foregoing heads.

And we ſhall begin with what was taken notice of by the Dutch in their *Nova Zembla* voyage, where relating, how they faſtened their ſhips to a great piece of ice, to ſhelter themſelves from the ſtormy winds; 'There (add 'they) we went upon the ice, and wondered 'much thereat, it was ſuch manner of ice: 'for on the top it was full of earth, and there 'was found about forty eggs; and it was not 'like other ice, for it was of a perfect azure 'colour, like to the ſkies, whereby there grew 'a great contention of words amongſt our 'men, ſome ſaying, that it was ice, others that 'it was frozen land; for it lay unreaſonably 'high above the water, it was at leaſt eighteen 'fathom under the water, cloſe to the ground, 'and ten fathom above the water.'

The like blue colour in rocky pieces of ice, I remember I have ſomewhere found, to have been taken notice of by a modern † navigator; or whether the words of *Virgil*, concerning the frigid zone, *Cærulea glacie concretæ, atque imbribus atris*, belong to this ſubject, I leave others to conſider, nor ſhall I ſtay to examine, whether this blueneſs, that has been obſerved in ice, be always an inherent or permanent colour, or ſometimes one of thoſe, that are ſtyled emphatical.

It is very conſiderable, if it be true, what is related by *Olaus Magnus*, concerning the degenerating (if I may ſo ſpeak) of ice from its wonted hardneſs in the ſpring of the year. For in the ſame chapter, where he gives us the lately tranſcribed account of the ſtrength of ice in thoſe northern countries, after having interpoſed ſome other paſſages, he ſubjoins theſe words; *Liquieſcente tamen glacie ad principium Aprilis, nullus ejus ſpiſſitudini, minus fortitudini, niſi in aurora, ambulando confidit, quia ſolis diurno aſpectu tam fragilis redditur, ut quæ equeſtres armatos paulo ante portaverat, vix hominem nunc ſufferre poſſit inermem.* *Olaus*, lib. 1. cap. 14.

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This

* —— *Sæpe aliàs & his annis fatalibus tam profundè congelavit (marina aqua) ut non tantum plauſtra, ſed integrum exercitum ad aliquot milliaria Germanica ſecurè vexerit, &c. Inquit* T. Barthol *de nivis uſu*, pag. 43.

† In the evening we were incloſed amongſt great pieces (of ice) as high as our poop, and ſome of the ſharp blue corners of them did reach quite under us. Captain *James*, page 6.

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THIS puts me in mind to add, that oftentimes in the writers of journeys and voyages, we meet with mention of great noiſes made by the breaking of ice; and in this very chapter our archbiſhop taking notice of the clefts, that ſometime happen in champions of ice, adds, 'That when the ice chances thus to 'open, eſpecially if it be in the night, the 'noiſe of it may be heard a far off, like the 'loud and horrid noiſe of thunder, and of 'earthquakes.' And on this occaſion may be ſubjoined a couple of paſſages extant in different places of the formerly mentioned *James Hall*'s voyages: the firſt is thus delivered; 'When we met with a huge and high iſland of 'ice, we ſteering hard to board the ſame, and 'being ſhot a little to northwards of it, there 'fell from the top thereof ſome quantity of 'ice, which in the fall did make ſuch a noiſe, 'as though it had been the report of five 'cannons.' But the next paſſage is more directly pertinent to our preſent ſubject, and is couched in theſe words; 'About twelve of 'the clock this night, it being ſtill calm, we 'found our ſelves ſuddenly compaſſed round 'about with great iſlands of ice, which made 'ſuch a hideous noiſe, as was moſt wonder-'ful, ſo that by no means we could double 'the ſame to the weſtward: wherefore, *&c.*'

OF theſe kind of icy thunders (as ſome travellers call them) there are divers inſtances to be met with, mentioned in the ſeveral voyages of the Hollanders, and particularly in thoſe to *Nova Zembla:* but many of thoſe noiſes ſeem to be made by the daſhing of the great pieces of ice againſt one another; but if it happens, when the ice (as ſometimes it is ſaid to do) ſeems to cleave, as it were, of its own accord; to us, that live in a temperate climate, it may be a matter of ſome diſpute, whence theſe loud ruptures of ice may proceed. For *Olaus Magnus*, in the chapter above cited, does not improbably aſcribe them to the warm exhalations, that in ſome places aſcend out of the ground. And I remember, in favour of this opinion, that I once cauſed divers pieces of thick ice to be brought out of a cool place into a ſomewhat warm room, and liſtening, obſerved a noiſe to come from them, as if it had been produced by ſtore of little cracks made in them; but ſomewhat or other prevented me from repeating the experiment, and ſatisfying my ſelf about the conjecture. But having lately inquired of an intelligent Polander, that has travelled much upon theſe icy plains, he agreed with our author, and others, as to the frightful noiſes, that are produced by theſe cracks of ice, but affirmed, upon his own obſervation, (for that I particularly inquired after) that theſe great clefts were often made, not by thawing heat, but by exceſſive cold, and that he had taken notice of them in extremely ſharp weather. Indeed we ſometimes obſerve, that in very bitter froſts the frozen ground will cleave, as we elſewhere have occaſion to take notice. But whether that be not a different caſe from this, or whether the Polonian gentleman were not miſtaken, or whether both theſe mentioned accounts, of the cleaving of ice, may on different conjunctures of circumſtances take place, we leave to farther inquiry.

THERE is a tradition concerning ice, about the famous *Vulcano Hecla*, in *Iceland*, which, though verily believed among the ſuperſtitious vulgar of thoſe parts, is ſpoken of ſo ſlightly by *Blefkenius*, who being upon that coaſt, had the curioſity to ſail purpoſely thither, that I think it not worth while to take any farther notice of it. But it were too tedious to ſet down in this ſection, (which the ſtrangeneſs and variety of the theme has made ſo prolix already) the other things, that may be mentioned without impertinency concerning ice; and therefore we ſhall here deſiſt from ſo laborious a taſk, as alſo omit the handling of ſnow and hail: for though they are reducible to ice, yet I ſhall at leaſt ſuſpend the treating of them, partly becauſe *Bartholinus* and meteorologiſts have ſaved much of my labour, and partly for the reaſon newly intimated: ſo that we ſhall conclude this ſection, as ſoon as we have taken notice, that there is yet ſomewhat relating to ice, which, being in it ſelf conſiderable, and whereof hitherto no experimental account appears to have been given, what we our ſelves have tried about it, may challenge to be treated of apart.

Olaus Magnus lib. 11. *& Blefkenius in Purch.* l. 3. c. 22.

TITLE XVI.

Experiments and obſervations touching the duration of ice and ſnow, and the deſtroying of them by the air and ſeveral liquors.

1. IT may be an experiment, as well inſtructive as new, to determine, what liquor diſſolves ice ſooner than others; and in what proportion of quickneſs the ſolutions in the ſeveral liquors are made. For men have hitherto contented themſelves to ſuſpect in general, that there are other liquors, potentially hot, wherein ice will ſooner diſſolve, than it will in water. But this opinion either being grounded upon no experience at all, or taken up upon the ſight of what happens to pieces of ice, which no care was taken to reduce to the ſame bulk and figure, no more than to meaſure attentively how long one outlaſted the other; we thought fit to try, if we could not bring this matter to experiment, and make a determination in it, though not exactly true, yet leſs remote from exactneſs, than had been yet, for aught I know, ſo much as attempted.

2. IN order to this, we procured ſome bullet moulds, and having firſt carefully ſtopped the little crevice, that is wont to remain betwixt the two halfs of the mould, with a good cloſe cement, we afterwards filled them with water, and carefully cloſed up the orifice of the hole, at which the water was poured in; and then ſetting the mould to freeze in ice and ſalt, we found it difficult enough to keep the water (more or leſs of it) from running away through ſome unperceived paſſage, before the cold could have time by congealing it to arreſt it. But after a while, when we had thus made a bullet of ice, we found it a new and greater difficulty to get it whole out of the moulds, without

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without warming them; for by that way we could indeed looſen the ice, but then we could not avoid thawing it too, and that moſt times not uniformly: wherefore we tried by greaſing the inſide of the moulds to keep the ice from ſticking ſo cloſe to them, (notwithſtanding the diſtenſion the water ſuffered by its being frozen) but that we might pick out the bullet entire; and this ſucceeding well enough, we hoped by this way to obtain our end, which was to have a competent number of pieces of ice of equal bulk, and of the ſame figure, to be put at once to thaw in ſeveral liquors. But we could by no means procure moulds, which had any number of diſtinct cells of the ſame bigneſs, thoſe long pairs of moulds, that were to be met with in ſhops, having their diſtinct cells generally made on purpoſe of very different bigneſſes, which rendered them altogether uſeleſs for our deſign. Wherefore we were fain, for want of an exacter way, to take a glaſs pipe of the moſt even and cylindrical that we had, and of a bore capable to admit a big man's little finger. This glaſs being ſtopt at one end, and kept open at the other, was filled to the height of about half a foot or more of fair water; and ice and ſalt being heaped up about it, that the cold might reach as far as the water did, it was quickly frozen. In the mean while I had cauſed ſeveral wide-mouthed glaſſes to be brought into my chamber (wherein, by reaſon of ſome indiſpoſition, that hindred me from going abroad, I kept ſome fire) and having poured ſeveral liquors into theſe glaſſes, which had been placed all on a row, we ſuffered them to reſt there a while, that the ambient air might have time to reduce them, as far as it could, to its temper, and conſequently to the ſame temper as to heat and cold: and then, with the warmth of one hand, the included ice being looſened from the glaſs, as it was taken out, and a ruler divided into inches and eighths, being laid alongſt it, with a knife a little warmed, the ice was ſoon, and yet not carelefly, divided into ſeveral ſmall cylinders of three quarters of an inch apiece; and theſe cylinders thus reduced to as ſenſible an equality as we could, were nimbly and carefully put into the ſeveral liquors hereafter to be mentioned. And whilſt we our ſelves watched very attentively, till each of theſe icy cylinders was quite, and yet but juſt diſſolved, we cauſed others to keep time by the help of a pendulum, whoſe vibrations were each a ſecond minute, (or 60th part of a common minute, whereof 60 go to make an hour;) and it was eaſy for thoſe we appointed, to watch the vibrations of the pendulum, notwithſtanding the quickneſs of its motion, becauſe it was fitted to a little inſtrument purpoſely contrived for ſuch nice obſervations, wherein a long index moving upon a divided dial-plate did very manifeſtly point out the number of the diadromes made by the pendulum.

3. THIS experiment was afterwards repeated twice with cylinders of ice, each of them an inch long; and though the ſucceſſes of theſe trials were various enough, yet we ſhall ſubjoin both the ſalt, (as being made with more advantage than the laſt) that the more light may be gathered from them, and that at leaſt we may diſcover, how difficult it is to make ſuch experiments in this matter, as that all the nice circumſtances of them may ſafely be relied on.

I. *Trial.*

1. OIL of vitriol, where a cylinder of ice, of an inch long, being put into, laſted five minutes.

2. SPIRIT of wine, (in which the ice ſunk) laſted 12 minutes.

3. AQUA FORTIS laſted 12 ½ minutes.

4. WATER laſted 12 minutes.

5. OIL of turpentine laſted (not good) 44 minutes.

6. AIR laſted 64 minutes.

II. *Trial.*

1. IN oil of vitriol, where an inch of cylindrical ice laſted 3 minutes.

2. IN ſpirit of wine, laſted 13 minutes.

3. IN water, laſted 26 minutes.

4. IN oil of turpentine, laſted 47 minutes.

5. IN ſallet oil, laſted 52 minutes.

6. IN the air, laſted 152 minutes.

4. WE likewiſe thought it worth trying, whether there would be any difference, and how much difference there would be in the duration of pieces of ice of the ſame bulk and figure, ſome of them made of common water, and others of frozen wine, milk, oil, urine, and other ſpirituous liquor; theſe ſeveral pieces being expoſed to be thawed in the ſame air, as other ambient liquor.

5. WE alſo tried, whether motion would impart a heat to ice, by nimbly rubbing a ſtrong piece of ice upon a plate of ice; and though this ſeemed to haſten the diſſolution in that part of the icy plate, where the attrition had been made, yet we were unwilling to determine the matter, till further and exacter trial have been made.

6. AND this brings into my mind an experiment, that has by ſome been thought very ſtrange. The occaſion I remember was, that I received the laſt winter the honour of a viſit from a nobleman of great eminency and learning, who chancing to come in, while I was making ſome trials with ice, would needs know what I was doing with it; but the preſence of a very fair lady, in whom *Hymen* had made him happy, and of ſome other company of that ſex, that he brought along with him, inviting me to give him the anſwer, that I thought would be moſt ſuited and acceptable to his company, I merrily told him, that I was trying, how to heat a cold liquor with ice; and to ſatisfy him, that was no impoſſibility, I held out an open-mouthed glaſs, full of a certain liquor (which for ſome juſt reaſons I do not deſcribe, but do plainly teach it in an opportuner place) and deſired them to feel, whether it were not actually cold. And when they were ſatisfied it was ſo, I choſe among the pieces of ice, that lay by me, that I judged by the eye to be fit for my purpoſe, (for every piece was not

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not ſo, for a reaſon I elſewhere ſhew,) and throwing it into this liquor, it did not only in a trice vaniſh in it, but the lady, I was mentioning, ſeeing the liquor ſmoke, and advancing haſtily to try, whether it were really warm, found it ſo hot, that ſhe was quickly fain to let it alone, and had almoſt burnt her tender hand, with which ſhe had, in ſpite of my diſſuaſion, taken hold of the glaſs, which her lord himſelf could ſcarce endure to hold in his. But this experiment, which for the main I have repeated before competent witneſſes, though it be not impertinent to the *Hiſtory of Cold*, yet I ſhall not build much upon it; becauſe, how ſtrange ſoever many have been pleaſed to think it, I ſhall elſewhere ſhew, that I made uſe of a certain unperceiveable ſleight, which, in my opinion, did as well, as the nature of the liquor and the texture of the ice, contribute to the ſuddenneſs and ſurprizingneſs of the effect.

7. BUT to return to the duration of the effects of cold, I think thoſe much miſtaken, who imagine, that the effects of cold do continually depend upon the actual preſence and influence of the manifeſt efficients, as the light of the air depends upon the ſun, or fire, or other luminous body, upon whoſe removal it immediately ceaſes. For when cold agents have actually brought a diſpoſed ſubject to a ſtate of congelation, though the manifeſt efficient cauſe ceaſe from acting, or perhaps from being, the effect may yet continue. For in moſt caſes, if a certain texture be once produced in a body, it is agreeable to the conſtancy of nature, that it perſevere in that ſtate, till it be forcibly put out of it, by ſome agent capable to overpower it. And though we uſually ſee ice and ſnow, as it were of their own accord to melt away, when the froſty conſtitution of the air ceaſes; yet the cauſe of that may be not barely the ceſſation of froſty weather, but that thoſe eaſily diſſoluble bodies are expoſed to the free air, which being heated by the ſun-beams, and perhaps by calorifick expirations from the earth, is furniſhed with an actual cauſe, upon whoſe account it deſtroys the texture of the ice and ſnow. But even here above ground, if ſnow be well compacted into great maſſes, in which, by reaſon of the cloſeneſs of the little icicles, but little air is allowed to get between them, I have ſeen ſuch maſſes of ſnow laſt ſo long, not only in thawing, but in rainy weather, as to be wondered at; and if ſuch ſnow (or ice) be kept in a place where it may be fenced from the ſun, and other external enemies, though the place, it is lodged in, be not any thing near cold enough to produce ice, yet it will, as ſome trial hath taught me, preſerve ice and ſnow for a very long time.

Appendix to the XVIth *Title.*

AN eminent inſtance to confirm what is delivered at the cloſe of the foregoing ſection, is afforded us by the conſervatories, wherein ſnow and ice are kept all the ſummer long. Of theſe I have ſeen in *Italy*, and elſewhere; but ſuppoſing I had the command of ſome Italian, and other books, wherein I ſhould meet with the dimenſions, and other circumſtances, that belong to them, my finding my expectation diſappointed by thoſe books, makes me think it very well worth while to ſubjoin ſomewhat about things, that may give us opportunity of making a multitude of experiments about cold. And therefore meeting the other day (by good chance) with my ingenious friend Mr. *J. Evelyn*, his inquiſitive travels, and his inſight into the more polite kinds of knowledge, and particularly architecture, made me deſire and expect of him that account of the Italian way of making conſervatories of ſnow, that I had miſſed of in ſeveral authors; and having readily obtained my deſire of him, I ſhall not injure ſo juſtly eſteemed a ſtyle as his, to deliver his deſcriptions in any other words, than thoſe enſuing ones, wherein I received it from him.

[THE ſnow-pits in *Italy*, *&c.* are ſunk in the moſt ſolitary and cooled places, commonly at the foot of ſome mountain or elevated ground, which may beſt protect them from the meridional and occidental ſun: 25 foot wide at the orifice, and about 50 in depth, is eſteemed a competent proportion. And though this be excavated in a conical form, yet it is made flat at the bottom or point. The ſides of the pit are ſo joiced, that boards may be nailed upon them very cloſely jointed. (His Majeſty's at *Greenwich*, newly made on the ſide of the Caſtle-hill, is, as I remember, ſteened with brick, and hardly ſo wide at the mouth.) About a yard from the bottom is fixed a ſtrong frame or treſſel, upon which lies a kind of wooden grate; the top or cover is double thatched, with reed or ſtraw, upon a copped frame or roof, in one of the ſides whereof is a narrow door-caſe, hipped on like the top of a dormer, and thatched; and ſo it is compleat.

I have ſeen alſo the ſides lined with rceds long-ways, inſtead of boarding or ſteening.

To conſerve ſnow:

THEY lay clean ſtraw upon the grate or wattle, ſo as to keep the ſnow from running through, whilſt they beat it to a hard cake of an icy conſiſtence, which is near one foot thick: upon this they make a layer of ſtraw, and on that ſnow, beaten as before; and ſo continue a bed of ſtraw, and a bed of ſnow, S. S. S. till the pit be full to the brim. Finally, they lay ſtraw or reed (for I remember to have ſeen both) a competent thickneſs over all, and keep the door locked. This grate is contrived, that the ſnow melting by any accident in laying, or extraordinary ſeaſon of weather, may drain away from the maſs, and ſink without ſtagnating upon it, which would accelerate the diſſolution, and therefore the very bottom is but ſlightly ſteened. Thoſe, who are moſt circumſpect and curious, preſerve a tall circle of ſhady trees about the pit, which may rather ſhade, than drip upon it.]

THUS far this learned gentleman's account of conſervatories of ſnow. And on this occaſion I might add what the Dutch in their *Nova Zembla* voyage relate, namely, that 'the three 'and twentieth of *June*, though it were fair

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'ſun-ſhiny weather, yet the heat was not ſo 'ſtrong, as to melt the ſnow, to afford them 'water to drink; and that in ſpite of their 'being reduced to put ſnow in their mouths, 'to melt it down into their throats, they '. were compelled to endure great thirſt.' But becauſe it was in ſo cold a climate, that this duration of the ſnow was obſerved, I ſhall take notice, that in the *Alps*, and other high mountains, even of warmer climates, though the ſnow doth partly melt towards the end of ſummer; yet in ſome places, where the reflection of the ſun-beams is leſs conſiderable, the tops will even then remain covered with ſnow, as we among many others have in thoſe countries obſerved. And for further confirmation of the doctrine delivered at the end of this 16th title, I ſhall ſubjoin a paſſage, which having unexpectedly met with in an unlikely place of Captain *James*'s voyage, I think not fit to leave unmentioned here; not only becauſe it is the ſole artificial obſervation, that I yet met with, concerning the laſting of ice, and ſo may recommend to us the ingenuity of an author, whoſe teſtimony we ſomewhat frequently make uſe of; but becauſe the obſervation is in itſelf remarkable, and notwithſtanding the difference of places may ſerve for the purpoſe we alledge it: our navigator's words are theſe; *page* 101. 'I have in *July*, 'and in the beginning of *Auguſt*, taken ſome of 'the ice into the ſhip, and cut it ſquare two 'foot, and put it into the boat, where the ſun 'did ſhine on it with a very ſtrong reflex 'about it. And notwithſtanding the warmth 'of the ſhip (for we kept a good fire) and 'our breathings, and motions, it would not 'melt in eight or ten days.' And it is alſo conſiderable to our preſent purpoſe, what the ſame author elſewhere has about the durableneſs of the congelation of the ground not yet thawed at the beginning of *June*. 'For the 'ground (ſays he) *pag.* 65. was yet frozen; 'and thus much we found by experience in 'the burying of our men, in ſetting up the 'king's ſtandard towards the latter end of '*June*, and by our well at our coming away 'in the beginning of *July*; at which time 'upon the land, for ſome other reaſons, it 'was very hot weather.'

TITLE XVII.

Conſiderations and experiments touching the Primum Frigidum.

1. THE diſpute, which is the *Primum Frigidum*, is very well known among naturaliſts; ſome contending for the earth, others for the water, others for the air, and ſome of the moderns for nitre: but all ſeeming to agree, that there is ſome body or other, that is of its own nature ſupremely cold, and by participation of which, all other cold bodies obtain that quality.

2. BUT for my part, I think, that, before men had ſo hotly diſputed, which is the *Primum Frigidum*, they would have done well to inquire, whether there be any ſuch thing or no, (in the ſenſe newly expreſſed.) For though I make ſome ſcruple, reſolutely to contradict ſuch ſeveral ſects of philoſophers, as agree in taking it for granted, yet I think it may be not irrationally queſtioned, and that upon two or three accounts.

3. For (firſt) it is diſputable enough, as we ſhall hereafter ſee, whether cold be (as they ſpeak) a poſitive quality, or a bare privation of heat: and till this queſtion be determined, it will be ſomewhat improper to wrangle ſolicitouſly, which may be the *Primum Frigidum*. For if a body's being cold, ſignify no more than its not having its ſenſible parts ſo much agitated, as thoſe of our ſenſories, by which we are wont to judge of tactile qualities; there will be no cauſe to bring in a *Primum Frigidum*, upon whoſe account particular bodies muſt be cold: ſince to make this or that body ſo, it ſuffices, that the ſun or the fire, or ſome other agent, whatever it were, that agitated more vehemently its part before, does now either ceaſe to agitate them, or agitate them but very remiſsly, ſo that, till it be determined, whether cold be a poſitive quality, or but a privative; it will be needleſs to contend, what particular body ought to be eſteemed the *Primum Frigidum* (in the ſenſe above ſpecified.)

4. Secondly, though it be taken for granted, not only by the ſchools, but by their adverſaries the chymiſts, that heat and moiſture, dryneſs and gravity, and I know not how many other qualities, muſt have each of them a πρῶτον δεκτικὸν, or a principal ſubject to reſide in, upon whoſe account, and by participation of which, that quality belongs to the other bodies, wherein it is to be met with; though this be ſo, I ſay, yet we have * elſewhere fully enough manifeſted, that this fundamental notion, upon which much of the doctrine of qualities is both by Ariſtotelians, and vulgar chymiſts, ſuperſtructed, is but an unwarrantable conceit, and therefore not ſufficient for a wary naturaliſt to build the notice of a *Primum Frigidum* upon; there being indeed many qualities, as gravity, and figure, and motion, and colour, and ſound, &c. of which no true and genuine πρῶτον δεκτικὸν can (for aught I could ever yet diſcover) be aſſigned. And becauſe heat and cold are looked upon as diametrically oppoſite qualities, we may conſider, that it will be very hard to ſhew, that there is a πρῶτον δεκτικὸν of heat; ſince ſtones, and metals, and plants, and animals, and (very few excepted) all conſiſtent bodies, we are converſant with, may by motion be brought to heat; which to attribute to the participation of ſome portion or other of the imaginary element of fire, is not only precarious (being affirmed by many, and proved by none) but erroneous, or at leaſt needleſs, as we have more at large declared in other papers.

* *In the Sceptical Chymiſt.*

The Dialogues about Heat and Flame.

5. A third thing, that induces me to queſtion, whether there be a *Primum Frigidum*, is, that among thoſe bodies, that the chiefeſt ſects of philoſophers, whether ancient or modern, have pitched upon, there is not any, that ſeems clearly to deſerve the title of *Primum*

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mum Frigidum. But to make this appear, we muſt diſtinctly (though as briefly as our deſign will permit) conſider thoſe four ſeveral bodies, which we have (at the beginning of this ſection) taken notice of, to ſtand in competition, in the opinions of philoſophers, for the title of *Primum Frigidum.*

6. FIRST then, *Plutarch* and others contend, that it is the earth; but to omit other arguments, we ſee, that the earth is frozen not by its own cold, but by its vicinity to the air, as may be argued by this, *viz.* that the congealing cold, even in the midſt of winter, affects but the ſurface of the earth, where it borders on the air, and ſeldom pierces above a few feet, or, at moſt, yards, beneath that part, wherein the earth is expoſed, and immediately contiguous, to the air; as may appear by what we have formerly delivered concerning the ſmall depth, to which froſts reach in the ground. And therefore if the earth be protected from the air (though by ſo cold a body as water) it may be kept unfrozen all the winter long; as may be gathered from that remarkable practice in the great ſalt-marſhes of the French iſlands of *Xaintonge*, where, as a diligent writer of that country, very well verſed in the making of the French ſalt, informs us, when once the ſeaſon of coagulating ſalt by the heat of the ſun is quite paſt, the owners are careful, by opening certain ſluices, to overflow all the banks, and dams, that make and divide the ſalt-ponds, and ſerve for the workmen to paſs to and fro: for (ſays my author in his own language) if they left thoſe marſhes (or ſalt-works) uncovered, the froſt would make ſuch havock amongſt them, that it would be neceſſary to make them up again every year; but by means of the water they are preſerved (or kept in repair) from year to year. Which practice I the rather mention, becauſe the hint, it affords, as it is conſiderable to our preſent purpoſe, ſo it may on ſome occaſions be applicable to practices uſeful to human ſociety.

7. BESIDES, the earth being (according to thoſe we reaſon with) the coldeſt, heavieſt, and ſolideſt of elements, it is not ſo probable, as to excuſe them from need of proving it, that thoſe exceſſively cold agents, that freeze the clouds into ſnow and hail, ſhould be terrene exhalations carried up to the middle region of the air; eſpecially ſince it muſt be done by agents, either hard to be gueſſed at, or conſiderably hot. And it is not eaſy to give a reaſon, why, if elementary corpuſcles, ſteaming from the earth, have ſuch a congealing cold, where they are diſunited, and but interſperſed among the particles of air; the maſs of the earth it ſelf, whence thoſe exhalations are ſuppoſed to proceed, ſhould not be able alſo to congeal water, ſince the terreſtrial corpuſcles being more thick ſet, and united in a clod of earth, than in an equal portion of the atmoſphere, it ſeems, that where the frigorifick matter is more denſe, the cold ſhould be more vehement; as philoſophers obſerve, that heat is more intenſe in a glowing bar of iron, than an equal portion of the flame of kindled ſtraw.

8. BUT (not to repeat what we formerly mentioned about cold's being a privation) there is another argument againſt the earth's being the *Primum Frigidum*; and that is taken from the ſubterraneal fires, which breaking forth in many places of the earth, as in *Ætna*, *Veſuvius*, *Hecla*, the *Pico of Teneriffe*, &c. ſeem to argue a ſubterraneal fire; upon whoſe exiſtence not only many chymiſts build great matters, but even divers philoſophers have adopted it, as to employ it as one argument of the earth's being naturally neither hot nor cold. The mention of this ſubterraneal fire brings into my mind ſome things, that I have met with amongſt good, though not claſſick, authors, and amongſt men, that have been either diggers of, or converſant in, mines, not improper to be here taken notice of. For though I do not now intend to declare my opinion about the central fire, either of the chymiſts or Carteſians, and though the examples newly mentioned, and ſuch other, ſeem to me but very inconſiderable, in reference to the whole earth; yet it is obſervable to our preſent purpoſe, that there ſhould be ſo much ſubterraneal heat or warmth, at leaſt generally to be met with. For even where there appear no manifeſt ſigns of ſubterraneal fires, I have known thoſe, that were wont to go to the bottom of deep mines, complain, that a very little exerciſe would put them into a great ſweat; and a learned and experienced French doctor, that hath written in his own language, of ſtones and jewels, affirms, that in ſuch mines the ſubterraneal vapours and exhalations, are viſibly ſo abundant, and likewiſe ſo hot, that the mine-men are conſtrained (which a perſon I ſpoke with affirmed to me, touching himſelf) to work in their ſhirts, by reaſon of the great heat they there felt. And though I would have been glad to know, whether thoſe deep places would have appeared as hot, when judged of by a ſealed weather-glaſs, as they did to the mine-mens ſenſories, becauſe of ſome little doubt I harboured, whether much of that copious ſweating, and ſeeming heat, might not proceed from the thickneſs of the dampiſh air, and its unfitneſs for reſpiration; yet, becauſe a virtuoſo, that had a lead-mine of his own, in which he wrought himſelf for curioſity, anſwered me, that he was not wont to find any difficulty of breathing in the place, where he was ſo apt to ſweat; and ſince I find not, that others have complained of having their reſpiration incommodated in ſuch places, unleſs by accidental damps, my ſcruple was much abated; and the rather, becauſe the author lately mentioned expreſsly affirms, that the ſudorifick heat (if I may ſo ſpeak) is to be found in the bowels of the earth, as well in ſummer as in winter, which prevents the aſcribing of it to *Antiperiſtaſis*. And in other places than mines it is generally obſerved, that wells and ſprings freeze not, if the place whence the water is drawn be very deep; but, as we have obſerved elſewhere, that it oft comes up ſmoking, and, as it were, reeking; which argues, that at the leaſt the earth, wherein it was harboured, or through which it paſſed, was,

De Claves *au ſecond Livre des pierres & pierreries*, cap. 2.

Ibid.

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was, if not warm, free from ſuch a degree of cold, as might be expected in the earth, if it were the *Primum Frigidum*. Nor can it be reaſonably pretended, that the ſubterraneal heat comes from the beams of the ſun, ſince learned men have obſerved, that thoſe heat not the earth above ſix or ſeven foot deep even in Southern countries; and though we ſhould allow them to pierce three times as far, yet that would not be conſiderable to the depth of the mines above-mentioned; and if the lower part of the earth were of its own nature cold, and received the heat it diſcloſes only from the ſun and ſtars, the deeper men dig, the leſſer of heat and ſteams they would meet with; whereas the above-cited French mineraliſt affirms, that the lower they go, the more vapours, exhalations, and heat they find.

Monſieur de Claves, liv. 11. cap. 8.

9. But becauſe this learned man delivers this circumſtance in a dogmatical, rather than an hiſtorical way, I will add ſomewhat out of a relation (whence I have * elſewhere taken other particulars) made by a French phyſician likewiſe, that had the curioſity to deſcend himſelf into the deep mines of *Hungary*; ſome of which, that he went down into, may be collected by his narrative, to have three or four hundred fathom, that is, eighteen or twenty-four hundred foot of perpendicular depth. This author then relates, that after he had deſcended about 80, or 100 fathoms, he came into a very warm region of the earth, which laſted to the bottom of the mine, and is ſo hot both winter and ſummer, that the labourers are wont to work in it without their clothes, and he was ſcarce able to indure the heat of it, although the external air were very hot, the weather being very fair, and the month *July* †. He adds, that he having demanded of the overſeer of the mine, whence this heat came, he was anſwered to that and ſeveral other queſtions, that it came from the lower parts of the earth; that wherever they dig the ground, after they are come to ſuch a depth (which he elſewhere mentions to be about 80 or 100 fathom) they feel no more any cold, but a perpetual heat, how deep ſoever they dig, (‡ yet without obſerving, that after they are once got into that warm region, they find the heat ſenſibly increaſe, the nearer they approach to the centre of the earth, unleſs by accident they happen to dig through veins of hotter minerals.) And theſe anſwers (ſubjoins my author) I received not in one mine alone, or from a ſingle overſeer, but in all the mines, and from all the maſters of them; ſo that if theſe were not miſtaken, we may ſafely conclude, that as far as experience can inform us, the body of the earth in its lowermoſt parts, where it is preſumed to be coldeſt, is every where, and that conſiderably, hot. I ſaid if, *if theſe mine-men were not miſtaken*, becauſe having been in the bottom of ſome mines myſelf, though I find it acknowledged, that it is ſtill warm in the bottom of deep ones; yet I confeſs, I ſomewhat ſuſpect, by what I have obſerved, that this degree of heat, which our French phyſician found in the Hungarian mines, might be rather in great part from the peculiar nature of thoſe places, or of the minerals generated there, than barely (as he and thoſe, that informed him, ſuppoſe) from the greatneſs of their depth beneath the ſurface of the earth: for I know ſeveral mixtures, beſides thoſe that are common, of bodies neither of them actually hot, which will produce a conſiderable degree of heat. And very credible eye-witneſſes affirm, that in ſome parts of *England* they dig up a good ſtore of a kind of mineral, which is thought to be of a vitriolate nature, which, by the bare addition of common water, will grow hot, almoſt to ignition. So that the Hungarian mines being deep, as appears by our author's narrative, being not deſtitute of water enough to make a ſubterraneal ſpring in the mine itſelf, beſides what water may plentifully aſcend in the forms of vapours, and moiſten the ore, it may be ſuſpected, that either the water, or ſome appropriated mineral ſpirit or juice (of which the bowels of the earth may contain divers, that we know nothing of) may produce, together with the mineral, a warm ſteam, which, for want of ſufficient vent in thoſe narrow, and cloſe places, may heat them conſiderably. Which conjecture may be countenanced by theſe three circumſtances, that I took notice of in our author's narrative; one, that the ſmoke, that copiouſly aſcended out of the mine by the perpendicular grove, was not barely hot, but conſiſted of ſtinking exhalations, which were ſo ſaline, and fretting, as oftentimes to corrode and ſpoil both the wooden ladders or ſtairs, and the iron inſtruments of the diggers. The other, that the overſeers themſelves of the mines told *Morinus* (as we lately ſaw) that they in ſome places met with veins of hot minerals, which made it hotter than the bare vicinity of thoſe places to the centre of the earth would have done. And laſtly ‖, as our author was deſcending into the golden mine at *Cremnitz*, he found in one glace, the heat to increaſe as he deſcended more and more, (which ſeems not to agree with a paſſage we lately mentioned out of him) and to exceed any he had met with in any other mine; and afterwards the overſeer bringing him into a room, that abounded with ſmaragdine vitriol, (the

* In the diſcourſes about *Antiperiſtaſis*, the following paſſages are taken out of a ſmall narrative, conſiſting of about two ſheets of paper of *Jo. Baptiſta Morinus*, publiſhed in the year 1619, and entiled, *Relatio de Locis Subterraneis*, annexed to a diſcourſe (too much built on Aſtrological and Ariſtotelian grounds) of the threefold region, that he conceives to be as well in the earth as in the air.

† *Unde calor ille procederet petii à præfecto. Reſpondit, ex partibus inferioribus, inferius enim perpetuo calet. Quod reſponſum magis adhuc miratus, quæſivi an res ita ſeſe haberet in fodinis omnibus. Reſpondit ita ſe habere in omnibus, ſaltem profundis, ut poſt profundum terræ frigidæ tractum, in locum calidum deſcendatur. Et quod, ubicunque terra foditur poſt ſimilem profunditatem, nullum amplius ſentitur frigus, ſed ſemper calor, quantumcunque profundè fodiatur.*

‡ —— *Percunctatus ſum, an quo magis acceditur ad terræ centrum, calor ille major percipercetur. Reſpondit, id nunquam fuiſſe animadverſum, niſi interdum dum fodiendo occurrebant venæ calidorum mineralium.*

—— *Hæc reſponſa non in unicâ fodinâ, & ab unico præfecto accepi; ſed, &c.*

‖ *Cum deſcendendo calorem illam magis ac magis augeri ſentirem; hujus rationem petii à præfecto, quod in nullâ adhuc adinâ ſimilem caloris intenſionem percipiſſem. Reſpondit, minceam vitrioli paulo inferius exiſtere, quæ calorem multiplicaret.*

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mineral, whence this heat proceeded) though the room were ſpacious, he found there, beſides a ſharp ſpirit very offenſive to his throat, ſo troubleſome a heat, that he was ready to faint away with ſweating, and very much wondered how the diggers were able to work there. And elſewhere the author himſelf notes, that ſuch hot mines of vitriol, or ſulphur, may be found even in the firſt region of the earth, (as he calls that, which is ſomewhat near the ſurface, which he thinks fit to name the *cold region*) and within a large ſphere of activity make it perpetually hot. But this, as I was intimating, I mention but as a ſuſpicion, or a conjecture; and notwithſtanding that the degree of heat may be much increaſed in theſe mines, by the concurrence of accidental cauſes, in caſe the conjecture be admitted; yet the frequency of a ſenſible degree of heat in very deep places does very little favour their opinion, that will allow the earth to have no other heat but what it receives from the ſun-beams, or by the manifeſt fire of burning hills, as *Ætna* and *Veſuvius*. And if it ſhould be objected, that this ſubterraneal heat is adventitious to the earth, which is ſupremely cold of its own nature; *Gaſſendus* might reply, that it is as likely, that the coldneſs of it near the ſuperficies may be adventitious too, and that it appears at leaſt as manifeſtly, that the one proceeds from the contiguous air, as it does, that the other proceeds from ſome included fire. And if I miſremember not, he hath this conſideration, that it is ſomewhat ſtrange, that nature ſhould have intended the earth for its *Summum Frigidum*, and yet that a greater part (and for aught we know the greateſt) ſhould be conſtantly kept warm, either by the ſun, as under the torrid zone, or by the ſubterraneal fires. But the objection mentioned againſt *Gaſſendus* oppoſes but one of the arguments we have alledged againſt the earth's being the *Primum Frigidum*, and would leave the others in their force, though it did more convincingly anſwer that, againſt which it is framed, than it ſeems to do.

10. AND if the patrons of the earth's coldneſs, to evade the arguments I have alledged, ſhould pretend, that when they affirm the earth to be the *Primum Frigidum*, they mean not the elementary earth, but ſome body that is mingled with it; I ſhall deſire to know, which it is they mean, of the many other bodies, that make up the terreſtrial globe, that we may examine what right it has to that title. And in the mean time I ſhall conclude againſt them, that the earth it ſelf has none, ſince they grant a colder body than it, and ſuch a one as the earth muſt be beholden to, for the greateſt degrees of coldneſs it chances to poſſeſs.

11. BUT though, I preſume, enough has been ſaid to make it appear unlikely, that the earth ſhould be the *Primum Frigidum*, yet I muſt in this diſſent from the learned *Gaſſendus*, that he thinks the earth, not only not to be the *Primum Frigidum*, but not to be naturally cold any more than hot. For the inſenſible parts of the earth, like thoſe of other firm bodies, being heavy, and perhaps groſs, and either having no conſtant motion at all, or at leaſt a far more remiſs agitation, than that of our ſenſories; it ſeems to follow, that the earth muſt ſeem cold to us, unleſs it be, by the communicated heat, or motion of ſome extrinſick agent, put into a degree of agitation, that belongs not to its nature. And for the like reaſon I think it not improbable, that pure earth ſhould in its own nature be colder, than either pure water, or pure air; ſince the earth being a conſiſtent body, its component particles are at reſt among themſelves, or at leaſt moved with an almoſt infinite ſlowneſs; whereas water and air being fluids, their component particles muſt be in a reſtleſs and various motion, and conſequently be leſs remote from heat, which is a ſtate, wherein the various agitation of the minute particles is more vehement.

12. AND if thoſe, that plead for the earth, had declared, that they meant not the pure or elementary earth, but that part of the terreſtrial globe, that is diſtinct from the ſea, and other waters, that make it up, and would have earth in that ſenſe not to be the *Primum Frigidum*, but only the *Summum Frigidum*, perhaps they might have a better plea for their opinion, than they can urge for theirs, who contend for the water or the air; eſpecially, if, to countenance their opinion, this memorable obſervation be added, which I have met with among thoſe navigators, that have had the greateſt experience of the frigid zone; for the Dutch, that ſailed thrice to *Nova Zembla*, and once wintered there, * affirm in their firſt voyage, that the higheſt degrees of cold are not to be met with in the main ſea, where yet men are moſt expoſed to the operations of the air, and of the water, but either upon the land or near it. That accurate geometrician and hydrographer *Fournier* tell us, that in 1595, the Hollanders being intercepted by icy ſhoals in the ſtraight of *Weigats*, and meeting with certain Muſcovites, demanded of them, whether thoſe ſeas were always frozen; and were anſwered, that neither the northern ſea, nor that of *Tartary* did ever freeze; and that it was only that ſtraight, with the ſea contiguous to the ſhores of ſome bays and gulphs, that were frozen. And our judicious author not only adds, that in effect all thoſe, that ſail into thoſe parts, relate, that all thoſe lumps of ice are ſuch as have been looſened, and ſever'd from the iſlands, and the rivers of the *Samojeds* and *Tartars*, but adventures to affirm in general terms, that it is certain, the main ſeas never freeze, and that it is but the confines, and ſhores of ſome of them, that are frozen.

13. THAT the water is the *Primum Frigidum*, the opinion of *Ariſtotle* has made it to be that of the ſchools, and of the generality of

* It was not the ſea, nor the nearneſs unto the pole, but the ice about the land, that lett and hindred us (as I ſaid before;) for that as ſoon as we made from the land, and put more into the ſea, although it was much farther northward, preſently we felt more warmth, and in that opinion our pilot *William Barents* died, who notwithſtanding the fearful and intolerable cold that he indured, yet he was not diſcouraged, but offered to lay wagers with divers of us, that by God's help he would bring that pretended voyage to an end, if he held his courſe north-eaſt from the north cape. *Gerat de Veer in Puchas*, p. 474.

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of philoſophers. But I can as little acquieſce in this opinion, as in the former, not finding it agreeable to what experience teaches us.

14. For not to mention, that it would be very difficult to prove, that divers very cold bodies, as gold, and ſilver, and cryſtal, and ſeveral other fuſible ſtones have in them any water at all, to which their coldneſs may with any degree of probability be aſcribed; nor to urge the arguments, that ſome modern contenders for the ſupreme coldneſs of the air are wont to imploy; not (I ſay) to inſiſt on ſuch things, I ſhall content my ſelf to make uſe of this obvious φαινόμενον of cold, that in rivers, ponds, and other receptacles of water, the congelation begins at the top, where the liquor is expoſed to the immediate contact of the air; which ſufficiently argues, that the air is colder than the water, ſince it is able not only ſenſibly to refrigerate it, but to deprive it of its fluidity, and congeal it into ice: whereas if the water it ſelf were the *Primum Frigidum*, either it ought to be, at leaſt as to the major part of it, always congealed, or we may juſtly demand a reaſon, why, when it does freeze, the glaciation ſhould not begin in the middle, or at the bottom, as ſoon as at the top, if not ſooner. And our arguments againſt the precedency of the water in point of coldneſs may be ſtrengthened by this, that froſts are wont to be hardeſt, when the air is very clear, and freeſt from aqueous vapours; whereas in rainy weather, wherein ſuch vapours moſt abound, the cold is wont to be far more remiſs. To which we may add, what we lately delivered from the obſervation of navigators, that even in the frigid zone the main ſea, where yet the water is in the greateſt maſs, and ſo moſt likely, as well as advantaged to diſcloſe its nature, never freezes, though the ſtraits, and bays, and gulphs be frozen over; which argues, that the greateſt degrees of cold are rather to be aſſigned to the air, or to the earth, than to the water, which by the practice formerly mentioned of the maſters of the French ſalt-marſhes appears to be (when it is of a conſiderable depth) fitter to preſerve bodies from congelation, than to congeal them. Which inſtance I the rather repeat, becauſe it ſeems to argue, that the water is not ſo much as diſpoſed to receive any very intenſe degree of cold at a remote diſtance from the air. For though navigators tell us of exceeding thick pieces of ice, yet, as we have already elſewhere noted, we are not bound to believe, that the congealing cold has pierced any thing near ſo much as that thickneſs amounts to, from the ſuperficies of the ſea directly downwards: for though it were no great matter, if it did, in compariſon of that depth of the ſea, which, though the water be naturally cold, the ſharpeſt air is unable to congeal; yet we have elſewhere proved, that thoſe thick maſſes of ice are not ſolid and intire pieces, but rather heaps of many flakes, and other fragments of ice, which running upon one another, or ſliding under one another, are by the congelation of the intercepted water (and perchance half thawed ſnow) as it were, cemented together into miſhapen unwieldy maſſes: which conjecture agrees very well with that obſervation of the ingenious captain *James*, which he delivers in theſe words:

'It ſeldom rains after the middle of *Septem-*
'*ber*, but ſnows; and that ſnow will not melt
'on the lands, nor ſands: at low water, when it
'ſnows (which it doth very often) the ſands are
'all covered over with it, which the half-tide
'carries officiouſly (twice in twenty-four hours)
'into the great bay, which is the common ren-
'dezvous of it. Every low water, are the
'ſands left clear, to gather more to the increaſe
'of it. Thus doth it daily gather in this man-
'ner till the latter end of *October*, and by that
'time hath it brought the ſea to that coldneſs,
'that as it ſnows, the ſnow will lie upon the
'water in flakes, without changing its colour,
'but with the wind is wrought together, and
'as the winter goes forward, it begins to freeze
'on the ſurface of it, two or three inches, or
'more in one night; which being carried with
'the half tide, meets with ſome obſtacle (as
'it ſoon doth) and then it crumples, and ſo
'runs upon it ſelf, that in few hours it will be
'five or ſix foot thick; the half-tide ſtill flow-
'ing, carries it ſo faſt away, that by *Decem-*
'*ber* it is grown to an infinite multiplication
'of ice.' Thus far this navigator; to which I ſhall add another paſſage out of one of his countrymen, (Mr. *Hudſon*, famous for the northern diſcoveries, that bear his name) by which, added to what has been elſewhere delivered to the ſame purpoſe, we may be invited to believe, that the vaſt hills and iſlands of ice, that are to be met with about the ſtraits of *Weigats*, and elſewhere, are not generated of the ſea it ſelf. 'It's no marvel (ſays he, *Purchas*, lib. 3.
'cap. 15. p. 579.) that there is ſo much ice in
'the ſea towards the pole, ſo many ſounds
'and rivers being in the lands of *Nova Zem-*
'*bla*, and *Newland* to ingender it, beſides the
'coaſts of *Pecora*, *Ruſſia*, and *Greenland*, with
'*Lappia*, as by proof I find by my travel in
'thoſe parts.

15. But for all this, I think not fit, as does the ingenious *Gaſſendus*, and ſome others, to make the water indifferent, as to heat and cold. For, as I formerly noted concerning the earth, ſo I muſt now repreſent touching the water, that, ſetting aſide the heat of the ſun, which is but adventitious, where it does operate, and which leaves many vaſt portions of that element, which it does not conſtantly reach, the inſenſible parts of water are much leſs agitated, than thoſe of our ſenſories temperately diſpoſed, and conſequently may in regard of us be judged cold. For though water being a liquor, I readily allow it a various motion of its component corpuſcles, (that being requiſite to make a body fluid,) yet ſuch an agitation, which is ſufficient for fluidity, may be, and often is, far more remiſs, than that of the ſpirits, blood, and other liquors of ſo hot a ſanguineous animal as man; as we ſee, that urine, though after it has been long omitted, it continues a fluid body, yet its parts are far leſs agitated, than they were, when it came hot, and reeking out of the bladder.

16. And upon this occaſion, I ſhall add, what by inquiry I have learned, that (except the

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the parts ſomewhat near the ſuperficies of the water, which the heat of the ſun, or the warmth of the neighbouring lower region of the air may give ſome warmth to) the whole body of the ſea is very cold: for being very well acquainted with one, that for ſome time got a livelihood by going down into the bottom of the ſea, to fetch up what could be recovered out of ſhipwrackt veſſels, I purpoſely inquired of him, what cold he felt under water; and he more than once told me, that though near the top of the water the cold were very moderate, yet when he was neceſſitated to deſcend a great depth, he found it ſo great, that he could not very long ſupport it. And particularly he told me, that having occaſion to deſcend about twelve or fourteen fathom deep (which is nothing in compariſon of the depth of many ſeas) to faſten ropes to the ordnance of a great ſhip, that was ſome years ſince caſt away, near the coaſt of one of the northern countries; though he was not incommoded in point of reſpiration, and though he felt no other inconveniencies, that might diſſuade his tarrying longer, yet the cold was ſo great, and troubleſome, that he was not able to endure it above two or three hours, but was conſtrained to remount to a milder, as well as higher region. I wiſhed ſeveral times he had had with him a weather-glaſs (for ordinary thermometers would on that occaſion have been unſerviceable) to prevent ſome little doubt, that might be made, whether the intenſe cold he felt might not be only and chiefly in reference to his body, which might be ſo altered, and diſpoſed by this new briny ambient, as to make ſuch a diſturbance in the courſe or texture of his blood, as that, which makes aguiſh perſons ſo cold at the beginning of the fit, though the temperature of the ambient body continue the ſame. But this is not the only perſon, that found the ſea exceeding cold; for I remember *Beguinus* relates from the mouth of a Marſeillian knight, that was overſeer of the coral-fiſhing in the kingdom of *Tunis*, that having upon that coaſt let down a young man, to feel whether coral were hard or ſoft, as it grew in the water, when this man was come about eight fathom, near the bottom of the ſea, he felt it exceeding cold. To which we ſhall add the teſtimony of a ſober traveller *Joſephus Acoſta*, who tells us, 'That it is a thing remarkable, that in depth of the ocean, the water cannot be made hot by the violence of the ſun, as in rivers: finally (he ſubjoins) even as ſalt-petre (though it be of the nature of ſalt) hath the property to cool water, even ſo we ſee by experience, that in ſome parts and havens, the ſalt water doth refreſh; the which we have obſerved in that of *Callao*, where they put the water or wine, which they drink, into the ſea in flaggons to be refreſhed: whereby we may undoubtedly find, that the ocean hath this property, to temper and moderate the exceſſive heat.' For this cauſe we feel greater heat at land than at ſea, *cæteris paribus*, and commonly countries lying near the ſea are cooler than thoſe that are farther off. By all theſe teſtimonies, it ſeems to appear, that both in very cold regions, and very hot, the deep parts of the ſea ſeem to be very cold, the ſunbeams being not able to penetrate the ſea to any great depth: for I remember, that having enquired of the diver I lately mentioned, whether he could diſcern the light of the ſun at any great diſtance from the ſurface of the water, he anſwered me, that he could not; but as he went down deeper and deeper, ſo he found it darker and darker, and that to a degree, that would ſcarce have been expected in ſo diaphanous a body as water is.

Beguinus in Tyrocinio Chymico, lib. 2. c. 1.

Joſephus Acoſta lib. 2. cap. 11.

17. BUT this ſubmarine cold (if I may ſo call it) though it be great and conſiderable, is not ſo intenſe, as to intitle water to be the *Primum Frigidum*; ſince as cold as our divers found it at the bottom of the ſea, they did not find it cold enough to freeze the water, as the air often does at the top.

18. THE next opinion, we are to conſider, is that of the Stoicks of old, and adopted by the generality of modern philoſophers, that are not Peripateticks, who aſſert the air to be the *Primum Frigidum*: but being ere long more particularly to treat of the temperature of the air, we will reſerve till then to examine, whether it be cold of its own nature or not; but in the mean time, we ſhall here take leave to queſtion, whether it ought to be eſteemed the *Primum Frigidum*. For not to mention, that *Ariſtotle*, and the ſchools, with many other learned men, think the air ſo far from being the coldeſt of the elements, that they reckon it among the hot ones, becauſe I confeſs their opinion is not mine, not to repreſent the heat of the air in the torrid zone, nor that by the generality of philoſophers, the upper region of the air, which is believed to make incomparably the greateſt part of it, is always hot, and the lower region is ſo too, in compariſon of the middle, though the coldneſs even of this is not perhaps unqueſtionable; not to urge any of theſe things, I ſay, I ſhall in this place mention only two obſervations.

19. THE one is that, which I lately recited, touching the great coldneſs of the water in the deeper parts of the ſea; for it is not eaſy to ſhew, how this great cold proceeds from that of the air, whoſe operation ſeems not (as may be judged by that little way that froſts pierce into the moiſt earth) to reach very far beneath the ſurface of the water, (inſomuch that captain *James*, who had very good opportunity to try, allows not, in caſe the ice be not made by accumulation, that the froſt pierces above two yards perpendicularly downwards from the ſurface of the water, even in the coldeſt habitable regions.) And this will ſeem the more rational, if we conſider, that in caſe the coldneſs of the ſea proceeded conſtantly from the air, as ſuch, the cold would be greater near the ſurface, where it is contiguous to the air, than in the parts remoter from it; and yet the contrary may appear by the paſſages lately recited.

20. BUT if it be objected, that this at beſt can prove no more, than that the air is not the *Primum Frigidum*; notwithſtanding which,

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it may be the *Summum Frigidum*. For anſwer, I muſt proceed to my ſecond argument, which will perhaps evince, that it is not that neither; for by the ſame way of arguing, by which thoſe, I am now dealing with, endeavour to prove the air to be the coldeſt body in the world, I ſhall endeavour to prove, that it is not ſo: for their grand, and (as far as I remember) their only conſiderable argument is drawn from experience, which ſhews, that water begins to freeze at the top, where it is expoſed to the air. But to this vulgar experiment I oppoſe that of mine, which I have often mentioned already to other purpoſes, that by an application of ſalt and ſnow, I can make water, that would elſe freeze at the top, begin to freeze at the bottom, or at any ſide I pleaſe, and that much ſooner than the common air, even in a ſharp froſty night, would be able to congeal it: and when in exceeding cold weather the ambient nocturnal air had reduced a parcel of air, purpoſely included in a convenient glaſs, to as great a degree of condenſation as it could; I have more than once, by the external application of other things, been able to condenſe it much farther: which argues, that it is not the air as ſuch, but ſome adventitious frigorifick corpuſcles (taking that term, as I do in this treatiſe, in a large ſenſe) that may ſometimes be mingled with it, which produce the notableſt degrees of cold, or upon whoſe account the air produces them. And if theſe be duly applied, water will be congealed, whether air comes to touch the ſurface of it or no; nay, though bodies, which the air can never penetrate, nor congeal any of their parts, be interpoſed, as may appear by the experiments formerly mentioned of freezing water included in glaſs bubbles, and ſuſpended in oil of turpentine, and other uncongealed liquors; and it is worth taking notice of by them, that conclude the air's being the *Primum Frigidum*, from the water's beginning to freeze at the top, where it is contiguous to the air, that it is there alſo, where the ice begins to thaw.

21. BESIDES the three opinions we have hitherto examined, there is a fourth, that juſtly deſerves to be ſeriouſly conſidered; for the learned and ingenious *Gaſſendus* is ſuppoſed, though I doubt how truly, to be the author of it; and though, according to his cuſtom, he ſpeaks warily, and not ſo confidently of it, yet in his laſt writings he much countenances it; yet ſome eminently learned men, as well of our own, as of other nations, have reſolutely enough embraced it. According then to theſe, the congelation of liquors, and the cold we meet with in the air, water, and other bodies, proceeds from the admixture of nitrous exhalations, or corpuſcles introduced into them: and as I have a great reſpect for divers of theſe men's perſons, ſo I like very well, in their opinion, that they do not aſcribe the ſupreme degree of frigifactive vritue to the air itſelf, but to ſome adventitious thing, that is mingled with it: but whereas they pitched upon nitre, as the grand univerſal efficient of cold, I confeſs I cannot yet fully acquieſce in that tenet. For though I am not averſe from allowing ſalt-petre to be one of thoſe bodies, that are endued with a refrigerating power, and to be copiouſly enough diſperſed through ſeveral portions of the earth; yet, for aught I know, there may be not only divers other cauſes of cold, but divers other bodies qualified to be efficients of cold, as well as ſalt-petre.

22. AND firſt, if cold be not a poſitive quality, but the abſence of heat, the removing of calorifick agents will in many caſes ſuffice to produce cold; without the introduction of any nitrous particles into the body to be refrigerated. But becauſe it is diſputable, whether cold be a poſitive quality or no, we will urge this argument no further, till the controverſy be decided; and till then, as it will remain not improbable, we propoſe it as no other, but proceed to the next.

23. IN the ſecond place, I ſee not as yet any proof, that the great cold, we have formerly mentioned to be met with in the depths of that vaſt body, the ſea, eſpecially when it is greater elſewhere than nearer the top, where the air may better communicate its coldneſs to it, muſt be the effect of nitrous atoms, which muſt certainly ſwarm in prodigious multitudes, to be able to refrigerate every drop and ſingle particle of ſo ſtupendouſly vaſt a body as the ocean. Beſides that I remember not to have found or known it obſerved, that nitre, eſpecially in vaſt quantities, reaches near ſo deep in the earth, as thoſe parts of the ſea, that are found exceeding cold. And as the halituous part of nitre is more diſpoſed to fly up into the air, than drive down into the ſea; ſo we find no great documents of its having its groſſer and ſenſible parts abounding in the ſea-water, ſince the evaporations of that leaves not behind it ſalt-petre, but common ſalt. But theſe, though no light conſiderations, are not thoſe, that moſt weigh with me.

24. FOR, in the next place, I am not ſatisfied with the experiences I find alledged to prove, that it is by nitre, that the air and the neighbouring parts of the earth, and water (not to repeat the objections I lately borrowed from the ſea) receive their higheſt degrees of cold. For when *Gaſſendus* and others tell us, that it is nitre reſolved into exhalations, that makes the gelid wind, which refrigerates all things it touches, and penetrating into the water, congeals it; this, I ſay, to me will ſeem precarious, until *Gaſſendus* (or ſome other for him) tells us, what experiments they are (which he ſeems in one place to intimate) that this new doctrine depends on: for I confeſs, that for my part, I, who have perhaps had more opportunity to reſolve nitre, have ſeen no great feats, that the ſteams of it have done, more than thoſe of other ſaline bodies, in the production of cold; and the ſpirit of nitre, which is a liquor conſiſting of the volatile parts of that reſolved ſalt, not only does not (that I have obſerved) appear to the touch to have conſiderably, if at all, a greater actual cold, than that of divers other liquors, but ſeems to have a potential heat. For whether or no the exhalations of nitre be able to congeal water into ice, I have formerly

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obſerved, that the ſpirit of nitre or aqua fortis will diſſolve ice into water, very near, if not altogether as ſoon as the ſpirit of wine it ſelf; which inflammable liquor is generally acknowledged to be in a high degree potentially hot. If *Gaſſendus* did not mean ſuch ſteams of ſalt-petre as theſe, which I have been ſpeaking of, it had not been amiſs to have ſignified, what other kind of corpuſcles of reſolved nitre he meant, without leaving his reader to divine it: and if we may judge of other experiments, which we lately took notice, * that *Gaſſendus* ſeems to intimate by that, which he ſets down a little after, compared with that he had mentioned a little before; I am not likely much to be convinced by them, but ſhall rather be tempted to ſuſpect, that learned man might be impoſed upon by others to write that, as matter of fact, which he never had tried, and yet own not the having it by report. For whereas he ſeems to ſay, that diſſolved nitre mingling itſelf with water, freezes it, and that in ſummer; yet I muſt freely profeſs, that although ſome other learned moderns teach the ſame thing (but without any man's avouching it, that I know, upon his own experience) I, who am no ſtranger to nitrous experiments, have never been able to produce, or ſo fortunate, as to ſee any ſuch effect: and it is ſomewhat ſtrange to me, that chymiſts, who make ſuch frequent ſolutions of nitre, and oftentimes with leſs water than is ſufficient to diſſolve it all, ſo that by conſequence the proportion of the nitre to the water muſt have run through almoſt all the poſſible meaſures of proportion, ſhould never ſo much as by chance (as I can hear) have obſerved any ſuch matter. And that, which makes me thus interpret *Gaſſendus* his meaning, (though in one of the two paſſages, wherein he ſets down this experiment, he mentions alſo ſnow, or ice, to be added to the nitre) is, that in the firſt of thoſe two paſſages, he aſcribes the congelation to nitre alone, without ſpeaking of either ice or ſnow; and in the other place, not only his words ſeem to import, † that notwithſtanding the addition of the other ingredients, the corpuſcles of the nitre expiring out of the mixture, and penetrating into the water, are they, that make it freeze; but the exigence of his diſcourſe ſeems to require ſuch an interpretation: for to ſay, it is the corpuſcles of the nitre, that were harboured in the ice or ſnow, that freeze the water they invade, is no better than to beg the queſtion. For beſides that he ought to prove, that there are multitudes of the corpuſcles of nitre lodged in ſnow and ice; beſides this, I ſay, ſince theſe two bodies are ſaid to be water, before they were congealed, to grant what his explication ſuppoſes about ice and ſnow, is to grant in effect, that nitre alone (without ice or ſnow) can turn water into ice, which is the thing, that experience warranted us lately to deny. And if this be all, that is meant by the experiment, the mixing of nitre with the ice, or the ſnow, will ſignify very little, to evince what ſhould be proved. For, if inſtead of nitre you take ſea-ſalt, or the ſpirit of ſalt, nay, the inflammable part of wine, the experiment will ſucceed; and yet I think *Gaſſendus* would not have the corpuſcles of theſe bodies to be frigorifick, like thoſe of nitre; which yet they may be proved to be by the ſame argument, which is imployed to ſhew, that the corpuſcles of the nitre, which is added as a diſtinct ingredient to the ice, or to the ſnow, are the efficients of the congelation.

25. HAVING thus examined *Gaſſendus* his experiments, we will now, as our next and laſt argument touching this ſubject, ſubjoin our own, as far as we can find any of them among our notes; ſome of which follow in theſe words,

26. [As cold as they think ſalt-petre to be, who teach its ſpirituous parts to be the grand and catholick efficients of cold, yet we found, that it would diſſolve ice readily enough, as well as ſea-ſalt, *&c.* are wont to do, as we collected from this, that roch'd petre mingled with ice would freeze the vapours wandering in the air to the outſide of the ſingle phial, wherein we made the experiment, which the ice alone would not have done; and having placed ſome groſſer beaten nitre (of the ſame parcel) in little heaps here and there upon plates of ice, we manifeſtly found them to ſink into the ice, which argued their diſſolving it; and having put ſome of it upon a thick and ſmooth piece of ice, we found, that it had pierced a hole quite through it, whilſt the ſurrounding part of the ice remained of a good thickneſs.]

27. [WE took a large ſingle phial, almoſt full of water, and put it into as much roch'd petre, as by keeping it a good while by the fire's ſide, we could diſſolve in it; of which one mark was, that there remained a pretty deal of ſalt intire at the bottom of the liquor: this being expoſed to the air, during an extremely ſharp night, and a good part of the day, the ſolution was frozen ſo hard to the very top of the liquor, that having broken the glaſs, we could hardly break the included maſs. But at the bottom there appeared ſome liquor, with cryſtals of nitre well figured, that ſeemed to have ſhot in it, and argued the water to be ſufficiently impregnated with the ſalt.]

28. [As for the ſpirituous parts of nitre, ſo far forth as their temper, as to heat or cold, can be judged by diſtillation, and by weather-glaſſes, they are not actually more cold than ſome other liquors, and appear rather to be potentially hot, than cold; at leaſt, they ſeem indiſpoſed to turn water into ice, ſince we have tried, that the ſpirit of nitre will readily enough turn ice into water.]

29. THESE

* *Gaſſendi* Phyſ. Lib. 6. Sect. 1. pag. 399. *De qualitatibus rerum——ac addi quidem fortaſſis poteſt, præcipuæ frigoris ſemina, ſi quæ conſtant, potiſſimum ex frigorificis atomis abire in halinitrum corporaque ipſis affinia, quando experimur non exſolvi halinitrum, quin et penetrando in aquam, ipſam congelet, et univerſa a ſe contacta refrigeret, et abeundo in halitum creet gelidum ſeu frigidum ventum, ſed res pendet ex variis, quæ non poſſunt hoc loco commemorari, experimentis.*

† b. pag. 400. *Quomodo poſſunt corpuſcula nitri in aquam infuſi illam præter modum adeo frigidam reddere, imò et per æſtatem etiam congelare, dum nitrum nivi glacieive detritæ commiſtum lagenæ circumponitur, ipſæque præter corpus lagenæ penetrant in aquam contentam.*

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29. THESE three foregoing notes ſhew, that ſalt-petre is no ſuch wonderfully cold body, but that there are others colder, as being able to freeze water, which nitre could not congeal. Nay, they manifeſt, that nitre, which is ſaid to be the efficient of ice, does thaw and diſſolve it, and ſo ſeems, at leaſt in reference to it, to be rather hot than cold.

30. I ſhall add now one note more, to ſhew it does not always make water ſo much as equally cold with the common air; the experiment I find thus recorded.

31. [WE took a ſealed weather-glaſs, and by a little pulley faſtned to a frame, ſuſpended it in a ſolution of roch'd-petre, as ſtrong as we could make it, without heat; as appeared by a pretty quantity of nitre, that had continued ſome days undiſſolved in the veſſel, which was a beer-glaſs, with a flat bottom. After the ball of the weather-glaſs had been ſuſpended in this liquor, to try, whether the ambient air were not at this time colder than the liquor, (it being a cloudy and windy day, and betwixt the hours of 11, and 12.) though both the weather-glaſs and it had ſtood ſome days in the place; I lifted up the glaſs out of the water by the ſtring it hung by, that I might not touch it with my warm hands, and found the liquor in the glaſs to deſcend by degrees, about two diviſions (which were eighths of an inch;) and then by the ſtring lifting up the weather-glaſs, and putting again the ſolution of nitre under it, the included liquor was impelled up again two diviſions, and ſometimes two diviſions and a half: for to ſatisfy my ſelf the more fully, I repeated the experiment ſeveral times, and obſerved, that the included liquor uſually aſcended the firſt diviſion ſo faſt, that the eye could perceive its progreſs, and that the aſcent upon the immerſion in the diſſolved nitre was diſcernibly quicker than the deſcent, upon the removal of the weather-glaſs into the open air, though the ſpace both of the one and of the other were about, either two diviſions, or two diviſions and a half.]

32. IF it be here demanded, what then I think of the frigifactive virtue of nitre, I muſt anſwer, that I have not yet fully ſatisfied my ſelf concerning it: but thus much I am not willing to deny, that among divers other bodies, that upon ſeveral occaſions exhale from the terreſtrial globe, thoſe corpuſcles, that are of a nitrous nature, may be for the moſt part well qualified to refrigerate the air. And I am not indiſpoſed to think, that there may be ſtore of little ſaline bodies of kin to nitre, that (eſpecially at certain times) rove in great multitudes to and fro, in ſome parts of the atmoſphere; but that this aërial ſalt, which ſome moderns call volatile nitre, ſhould be true and perfect ſalt-petre, is more than I am ſure of, and that this ſalt alone ſhould be the *Summum Frigidum*, is more than as yet I am convinced of; eſpecially, ſince, for aught I know, there may be in the bowels of the earth, (whence I have ſeen many concretes digged out, whoſe very names and outſides are for the moſt part unknown, even to chymiſts themſelves) divers other bodies beſides ſalt-petre, whoſe ſteams may have a power of refrigerating the air, as great in proportion to their quantity, as thoſe of ſalt-petre. And ſince common ſalt in artificial glaciations is found to cooperate as powerfully as ſalt-petre it ſelf; and ſince it is undeniably a body, of which there is a vaſt quantity in the terreſtrial globe, and which by reaſon of the ſea, where it abounds, is exceedingly diffuſed; I ſee no great reaſon, why we may not as well eſteem that kind of ſalt among the catholick efficients of cold, and the rather, becauſe that the ſmalleſt corpuſcles our eye diſcerns of ſea-ſalt, are wont to be, (though not exactly) of a cubical figure: which is that figure, *Philoponus* informs us, the great *Democritus* of old (juſtly admired by *Gaſſendus*) aſſigned to the atoms of cold; whereas, according to *Gaſſendus* himſelf, the corpuſcles of nitre, at leaſt as far as ſenſe has informed us, are not the moſt conveniently ſhaped to produce cold, ſince he labours to ſhew, that the figure of frigorifick atoms is to be tetrahedrical or pyramidal: whereas the cryſtals, or grains, great or ſmall, into which good ſalt-petre ſhoots, are wont to be priſmatical, having their baſe ſexangular. But to return to what I was ſaying concerning the congealing of water with ice, I ſhall ſubjoin, that the ſame experiment countenances my conjecturing, that oftentimes it may not be emanations of one ſalt, or other body, but a peculiar and lucky conjunction of thoſe of two or more ſorts of them, that produces the intenſe degree of cold; as we ſee, that ice and ſnow themſelves have their coldneſs advanced (as to its effects) by the mixture either of ſea-ſalt or nitre, or ſpirit of wine, or any other appropriated additaments. Nay, I may elſewhere have occaſion to ſhew, that actual cold may be manifeſtly promoted, if not generated, by the addition of a body, that is not actually cold. But to all this I muſt add, that I doubt, whether any of thoſe ſaline or terreſtrial expirations, either ſingle or conjoined, be the adequate cauſes of cold; ſince, for aught I know, there may be other ways of producing it beſides the introduction of frigorifick, whether atoms or corpuſcles, of which we may have occaſion to take ſome notice hereafter. In the mean time, having diſcourſed thus long againſt the admitting a *Primum Frigidum*, I think it not amiſs to take notice once more, that my deſign in playing the ſceptick on this ſubject, is not ſo much to reject other men's probable opinions of a *Primum Frigidum*, as abſolutely falſe, as it is to give an account, why I look upon them, as doubtful.

TITLE XVIII.

Experiments and obſervations touching the coldneſs and temperature of the air.

1. I HAVE ſhewn in the former ſection, that the air is not the *Primum Frigidum*; but yet I cannot readily yield my aſſent to the opinion of the learned *Gaſſendus*, and ſome others, (who have written before and ſince him) that the air is of itſelf indifferent; that is, neither cold, nor hot, but as it happens to be made

made either the one or the other by external agents. For if we take cold in the obvious and received acceptation of the word, that is, for a quality relative to the ſenſes of a man, whoſe organs are in a good or middle temper, in reference to cold and heat; I am hitherto inclinable to think, that we may rather attribute coldneſs to the air, than either heat, or a perfect neutrality as to heat and cold. For to make a body cold as to ſenſe, it ſeems to be ſufficient, that its minute corpuſcles do leſs agitate the ſmall parts of our organs of feeling, than they are wont to be agitated by the blood, or other fluid parts of the body; and conſequently, if ſuppoſing the air devoid of thoſe calorifick and frigorifick atoms, to which the learned men, I was naming, aſcribe its heat and cold, it would conſtitute a fluid, which either by reaſon of the minuteneſs of its parts, or their want of a ſufficiently vehement motion, would leſs affect the ſenſory of feeling, than the internal liquors and ſpirits of the body are wont to do, and ſo it would appear actually cold. Nor is it neceſſary, that all liquors, much leſs all fluids, ſhould be as much agitated as the blood and vital humours of a human body, as we ſee (to omit what in the laſt ſection is mentioned about newly emitted urine, and to ſkip other obvious inſtances) in thoſe fiſhes and other animals, whoſe blood and analogous juices are always, and that in the ſtate, which paſſes for their natural ſtate, actually cold to our touch. And I ſee no ſufficient reaſon, why we ſhould not conceive the air even in its natural ſtate, (at leaſt as far forth as it can be ſaid to have a natural ſtate) to be one of the number of cold fluids. For as to the main, if not only, argument of *Gaſſendus*, and others, namely, that as we ſee the air to be eaſily heated by the action of the ſun, or the fire, ſo we ſee it as eaſily refrigerated by ice, and ſnow, and northerly winds, and other efficients of cold, and that heat and cold reign in it by turns in ſummer and in winter; this only proves, what I readily grant, that the air is eaſily ſuſceptible at ſeveral times of both theſe contrary qualities; but it does not ſhew, that one is not more connatural to it than the other; as we ſee, that the water may be eaſily deprived of its fluidity by the circumpoſition of ſnow and ſalt, and reduced to be fluid again by the ſun, or the fire; and yet, according to them, as well as to others, fluidity, not firmneſs, is the natural quality of water. But this is not that, which I lay moſt weight upon; for I conſidered, that it is manifeſt, and acknowledged by theſe learned men themſelves, that the heat of the air is adventitious to it, and communicated by the beams of the ſun, or of the fire, or by ſome other agents naturally productive of heat, as well in other bodies as the air. And it is alſo evident, that upon the bare abſence, (for aught elſe, that appears) of the ſun, or extinction of the fire, or removal of the other cauſes of heat, the air will, as it were, of its own accord, be reduced to coldneſs. Whereas, that there are ſwarms of frigorific atoms diffuſed through the air, from which all its coldneſs proceeds, is but an hypotheſis of their own, far from being manifeſt in itſelf, and not hitherto, that I know of, proved by any fit experiment, or cogent reaſon. And though in ſome caſes I am not adverſe to the admitting ſuch corpuſcles, as may in a ſenſe be ſtyled frigorific, yet I ſee not, why we ſhould have recourſe to them in caſes, where ſuch a bare ceſſation, or leſſening of former motion, as may eaſily be aſcribed to manifeſt cauſes, may ſerve the turn, as to a *ſenſible*, (for I now conſider not the cauſes of the *intenſer*) coldneſs in the air, without taking them in. And the opinion, I incline to, has at leaſt this advantage, that the air ſeems to be as rightfully termed cold, as iron, marble, mercury, cryſtal, ſalt-petre, and ſuch other bodies, which men unanimouſly look upon as ſuch; there being none of theſe, to which the argument imployed againſt the coldneſs of the air, is not applicable, ſave that the air being a fluid of a looſer and finer texture, does ſooner receive and loſe the impreſſions of heat and cold. And yet if a block of marble, for inſtance, or an iron bullet, were removed into one of thoſe empty ſpaces, that *Gaſſendus*, and ſome others, ſuppoſed to be beyond the bounds of this world, I ſee not, why it ſhould not be rather cold, than either warm, or in a ſtate of perfect neutrality; ſince when the corpuſcles of heat and thoſe of cold had extricated themſelves, and were flown away into the neighbouring vacuum, the component particles of the ſtone or metal, whoſe implicated texture would hinder their diſſilition, remaining much leſs agitated than our organs of feeling are by the warm blood and ſpirits, that vivify them, muſt, if applied to thoſe ſenſories, appear cold.

2. I SHALL not, upon this ſubject, ſpend any farther diſcourſe, ſince perhaps the diſpute either may be, or at leaſt may eaſily be made verbal; for in caſe thoſe I argue with, ſhould ſo explain their opinion, as not to deny, that in its own nature the air, left to itſelf, may be reputed cold in reference to the ſenſories of men, who are warm animals; but ſay, that nevertheleſs, comparing it indefinitely to other than human bodies here below, it is ſo eaſily ſuſceptible of both the contrary qualities, that neither of them ſeems predominant in it, and that when it is conſiderably either cold or hot, it is made ſo by adventitious agents; I ſhall not much contend with them, eſpecially if it can clearly be made out, that there are great quantities of ſuch cold ſpirits, as *Cabæus* and *Gaſſendus* ſuppoſed to be univerſally productive of cold (more or leſs) in all bodies, where they get admiſſion: but of theſe cold ſpirits more perhaps elſewhere; our principal buſineſs in this ſection being to deliver experiments and obſervations; and becauſe we ſhall mention but few of the former ſort, we will diſpatch them firſt.

[3. *November* the 20th, 1662. we took a weather-glaſs, filled to a convenient height, with well-rectified ſpirit of wine, and hermetically ſealed: this we incloſed in a glaſs receiver of a cylindrical form, of about two inches diameter, and about a foot and a half high, and

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and having cemented on the receiver, we let it alone for ſome hours, that it might be perfectly cool. Then drawing out the air, and watching it narrowly, we obſerved, that the liquor in the weather-glaſs deſcended a little, though but a very little, upon the firſt exſuction of the air, and a little, though it ſeemed ſomewhat leſs, upon the ſecond; but afterwards we did not find it ſenſibly to deſcend. This ſubſidence of the liquor, in all amounting to about the length of a barley-corn, we attributed to the ſtretching of the glaſs by the ſpring of the included air, when the ambient was withdrawn; and accordingly, upon our allowing a regreſs to the excluded air, we ſaw the ſpirit in the thermometer riſe about half a barley-corn's length to the place, whence it began to ſubſide. Afterwards we ſucked out, and let in the air of the receiver, as before, with like ſucceſs, as to the deſcent and remounting of the liquor.

4. *N. B.* We tried with a very hot handkerchief applied to a convenient place to the outſide of the receiver, whether the included weather-glaſs would receive impreſſions from it, the air, that was wont to be intermediate, being removed; but we did not find the liquor in the weather-glaſs ſenſibly to ſwell, either by this way, or by caſting upon it the concentrated beams of a candle trajected through a double convex-glaſs. But when the air was re-admitted into the cavity of the receiver, then the ſame handkerchief, heated afreſh, and applied, made the ſpirit of wine ſenſibly, though but little more, to aſcend: of which, yet it ſeemed ſomething difficult, by reaſon of the nicety of the experiment, to eſtimate with any thing of certainty the cauſe.] So that upon the whole matter, till the experiment be repeated in air of differing tempers, to verify, whether it was the withdrawing of the wonted preſſure, or the receſs of the ſubſtance of the air, that made the liquor included in the thermoſcope ſubſide, and till the experiment be repeated with the further obſervation of other circumſtances, (which reiteration of the trial we intended, but were by intervening accidents hindered) the recited experiments will not afford much more than good hints towards the diſcovery of the temperature of the air.

* *In the third preliminary diſcourſe.*

I Have elſewhere * taken notice, that air, included in veſſels ſufficiently ſtrong and well cloſed was not ſenſibly or at leaſt conſiderably condenſed by cold; but when the air was not ſo included, as not to be in ſome part or other expoſed to the preſſure of the outward air or atmoſphere, it would then by a degree of cold, capable to freeze water, be manifeſtly reduced into a leſs room. But how much this contraction or condenſation of the air may amount to, I did not there ſubjoin, nor has the meaſuring of it been, that I know of, attempted by any man. Wherefore we thought fit to endeavour ſomething in this kind, of which we ſhall annex a brief account, whereby it will appear upon the whole matter, that in the climate we live in, the cold does not ſo conſiderably condenſe the air, as moſt men ſeem to have hitherto imagined.

6. And firſt, it will not be amiſs to intimate, that among other ways we tried to meaſure the ſhrinking of the air by ſealing it up in glaſſes furniſhed with long and very ſlender ſtems, that by breaking off the tips of thoſe glaſſes immerſed under water, when by the cold air of a froſty night, or the circumpoſition of ſnow and ſalt, the included air was highly refrigerated, the water might (by the preſſure of the atmoſphere upon it) be impelled into the cylindrical cavity of the broken glaſs, and by its greater or leſſer aſcent therein ſhew, how much the internal air had been made to ſhrink upon the account of the cold. But this way, for reaſons too long to be here deduced, we found troubleſome and difficult to practiſe with any thing of certainty. Nor did we ever, that I remember, by this way, bring the refrigerated air to loſe above a 30th part of its former dimenſions.

7. We would have tried alſo to meaſure the condenſation of the air by the aſcent of water into the ſtem of a bolt-head, ſo invented, that the orifice of the ſtem might be under the ſurface of the water, and the bolt-head kept erected. But this way we diſapproved, becauſe it was likely (and indeed we found it ſo by experience) that the external air would firſt freeze the uppermoſt part of the water contained in the ſtem, and thereby hinder its aſcent, and perhaps occaſion the burſting of the lower part of the ſaid ſtem.

8. Wherefore, though for want of a ſufficient quantity of ſome liquor, that would neither freeze like water, and aqueous bodies, nor congeal like common oil, and the like unctuous juices, we found it for a while ſomewhat difficult to practiſe the experiment; yet bethinking ourſelves of the indiſpoſition, that brine has to congelation, we made ſo ſtrong a brine with common ſalt, that with it (and, as I remember, with oil of turpentine alſo, of which we chanced to have ſome quantity by us) we made divers trials, of which I had two among our collections, which we ſhall here ſubjoin; whereof the one informs us, that an egg being inverted into ſalt water, the cold of a froſty night made the air ſhrink in the pipe near five inches; and the other (which is the accurateſt I meet with among my collections) gives me this account, that *January* the 29th, the air extended into 2057 ſpaces, was by the cold of the ſharp and froſty night contracted into 1965 ſpaces; ſo that in extraordinarily cold weather, the moſt we could make the air loſe of its former dimenſions by the additional cold of the atmoſphere, was a twenty-ſecond part, and a little more than a third. And this was the greateſt condenſation of the air, that we remember ourſelves to have obſerved, though we were ſo careful, as after we had placed marks, where the incongealable liquor reached into the pipe, that when the internal air was expoſed abroad to the cold, we cauſed ſervants to watch, and from time to time to take notice (by placing marks) of the various aſcents of the liquor, eſpecially early in the morning, leſt we ſhould omit taking notice of the greateſt

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contraction of the air; which omiſſion (by reaſon that the coldneſs of the ambient air does oftentimes begin to be remitted before we can feel it to beſo) is not eaſily avoided without watchfulneſs.

9. BUT having thus obſerved the condenſation of included air by the natural and unaſſiſted cold of the external air, we thought fit to proſecute the trial ſomewhat further; and in regard we conceived the cold of a mixture of ſnow and ſalt to be far more intenſe, than that of the meer ambient air alone, we endeavoured to meaſure, as near as we could, how much the one exceeded the other. And though we found, that by proſecuting the lately mentioned trial in the glaſs-egg, by the application of ice and ſalt to the elliptical part of the veſſel, the liquor riſe by our eſtimate near four inches more (than thoſe five, which it had riſen already, upon the account of the refrigeration of the included air by the bare cold of the external;) yet by proſecuting the other experiment (made the 29th of *January*) at the ſame time, when we were making it, we did ſomewhat more accurately determine the matter. For by applying ice and ſalt to the outſide of the veſſel, we found, that the included air was contracted from 1965 ſpaces, to which the cold of the ambient air had reduced it, into 1860 ſpaces; ſo that the circumpoſition of ice and ſalt did as much, nay ſomewhat more, condenſe it, after the meer cold of the external air had contracted it as far as it could, than the bare, though intenſe, cold of the ambient air could condenſe it at firſt; and the greateſt degree of adventitious cold we were able to give, by the help of nature and art, did not make the air expoſed to it loſe a full tenth part of its former dimenſions. On which occaſion it may not be unworthy obſervation, that there is no greater diſparity betwixt the proportion, in which the cold was able to condenſe the air, and that, wherein the cold was able to expand water.

10. This is all that at preſent I think fit to ſay, concerning the intereſt, that winds may have in the temperature of the air. And therefore I will now proceed to thoſe other particulars, wherewith I not long ſince ſaid, that I intended to cloſe up this ſection; and I might on this occaſion ſubjoin many things, but partly haſte, and partly other conſiderations will confine me to thoſe, that relate to the effects of cold upon the air in a more general way.

11. AND firſt, we will obſerve, that cold may hinder, in an almoſt incredible meaſure, the warming operation of the ſun upon the air, not only in the hotteſt part of the day (for that may ſometimes happen, even in our climate) but at ſeveral times of the day, even in the heat of ſummer.

12. I remember I once accidentally met with an intelligent and ſober gentleman, who had ſeveral times ſailed upon the frigid zone, and though an intervening accident ſeparated us ſo ſuddenly, that I had not opportunity to obtain from him the reſolution of above two or three queſtions; yet this I learned of him belonging our preſent purpoſe, that by the help of a journal he kept, he called to mind, that upon the coaſt of *Greenland* he had obſerved it to ſnow all midſummer night; which affirmation of ſo credible a perſon imboldens me to add ſome other relations, which I ſhould elſe have ſcrupled at.

13. Mr. *Logan*, an Engliſh merchant, that wintered at *Pecora*, one of the northern towns of *Muſcovy*, relates, that being there at a great ſalmon-fiſhing, there happened about the cloſe of *Auguſt* (which in many countries is wont to be the hotteſt time of all the year) ſo ſtrong a froſt, which laſted till the fourth day, *Purchas*, *lib.* 4. *pag.* 542. 'That the 'Ozera was frozen over, and the ice driving 'in the river to and again, broke all the nets; 'ſo they got no ſalmon, no not ſo much as 'for their own victuals.'

14. CAPTAIN *G. Weymouth* mentions, that in *July*, though he was not near the latitude of *Nova Zembla*, much leſs of *Greenland*, yet ſailing in a thick fog, when by reaſon of the darkneſs it occaſioned, *Purchas*, *pag.* 811. 'he 'thought good to take in ſome of his ſails; 'when his men came to hand them, they 'found their ſails, ropes, and tacklings ſo 'hard frozen, that it did (ſays he) ſeem very 'ſtrange unto us, being in the chiefeſt time of 'Summer.

15. IN the fifth voyage of the Engliſh to *Cherry Iſland*, which lies betwixt 74 and 75 degrees of latitude, they obſerved, that the wind being at North-eaſt upon the 24th of *July*, 'it 'froze ſo hard, that the ice did hang on their 'clothes.' And in the ſeventh voyage (which was made three years after,) to the ſame iſland, they mention, *Purchas*, *pag.* 564. that on the 14th of *July*, 'the wind being northerly, they 'had both ſnow and froſt.'

Theſe voyages are extant in Purchas, lib. 1. cap. 13. *and this paſſage is in* pag. 560.

16. The next thing, that we ſhall take notice of, is the degree of cold, which the efficient cauſes of that quality, whatever they be, are able to produce in the air; but of this we muſt not here treat indefinitely, the ſtrange effects of cold upon other bodies being moſt of them produced by the intervention of the cold firſt diffuſed in the air, and thoſe are treated of in a diſtinct ſection: wherefore we ſhall now give two or three inſtances of the ſudden operations of the cold harboured in the air.

THE formerly mentioned Engliſh ambaſſador into *Ruſſia*, Dr. *Fletcher*, gives us two inſtances very memorable to our preſent purpoſe: *Purchas*, *pag.* 415: 'When you paſs '(ſays he) out of a warm room into a cold, 'you will ſenſibly feel your breath to wax 'ſtark, and even ſtifling with the cold, as you 'draw it in and out.' So powerfully and nimbly does the intenſely refrigerated air work upon the organs of reſpiration.

[AND whereas a very credible perſon, now chief phyſician to the *Ruſſian* emperor, being aſked by me concerning the truth of what is reported ſometimes to happen at *Maſcow*, and is reputed the eminenteſt proof, that is readily obſervable of the extreme coldneſs of the air, aſſured me, that he himſelf ſaw the water thrown up into the air fall down actually congealed

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into ice ; Dr. *Fletcher* confirms this report.] For our ambaſſador alſo ſays, *Purchas*, *pag.* 414. ‘ That the ſharpneſs of the air you may judge ‘ of by this, for that water dropped down, or ‘ caſt up into the air, congealed into ice, before ‘ it come to ground.’ And I remember, that inquiring about the probability of ſuch relations, he anſwered me, that being at the famous ſiege of *Smolenſko* in *Ruſſia*, he obſerved it to be ſo extremely cold in the fields, that his ſpittle would freeze in falling betwixt his mouth and the ground ; and that if he ſpit againſt a tree, or a piece of wood, it would not ſtick, but fall to the foot of it.

17. Among the phænomena of cold, relating to the air, I endeavoured to obſerve, whether, upon the change of the weather from warm or mild to cold and frosty, there would appear any difference of the weight of the atmoſphere by its being plentifully furniſhed with a new ſtock of ſuch frigorifick corpuſcles, as ſeveral of the modern philoſophers aſcribe its coldneſs to : but though I ſeveral times obſerved by comparing a good barometer (and ſometimes alſo unſealed weather-glaſſes, furniſhed one with a tincted liquor, and the other with quickſilver) with a good ſealed weather-glaſs, furniſhed with pure ſpirit of wine, that, upon the coming in of clear and frosty weather, the atmoſphere would very early appear ſenſibly heavier than before, and continue ſo, as long as the cold and clear weather laſted ; yet by reaſon of ſome conſiderations and trials, that bred ſome ſcruples in me, I refer the matter to more frequent and laſting obſervations, than I yet have been able to make ; in which it will concern thoſe, that have a mind to proſecute ſuch trials, not only to conſider, whether or no the increaſed gravity of the atmoſphere may not proceed from ſome other cauſe, than the coming of frigorifick atoms into the air ; but to have a ſpecial care, that their baroſcopes be more carefully freed from the air, that is wont to lurk in quickſilver it ſelf, as well as other liquors, than thoſe, in the making of the Torricellian experiment, tubes uſually are, leſt that air getting up into the deſerted part of the tube, do, by its expanſion and contraction, obtain an unſuſpected intereſt in the riſing and falling of the ſubjacent mercurial cylinder, and ſo impoſe upon them.

18. Another effect, that the cold, eſpecially in northern countries, has oftentimes upon the atmoſphere, is, the making the air more or leſs clear than uſually it is. For in the northern voyages, the ſeamen frequently complain of thick and laſting fogs, whoſe cauſes I ſhall not now conſider, but ſome help to gueſs at them may be given by what we are about to add ; namely, that it frequently happens, on the contrary, that when the cold is very intenſe, the air grows much clearer than at other times, probably becauſe the cold by condenſing precipitates the vapours, that thicken the air, and by freezing the ſurface of the earth, keeps in the ſteams, that would elſe ariſe to thicken the air. Not to diſpute, whether it may not alſo ſomewhat repreſs the vapours, that would be afforded by the water it ſelf, ſince ſome of our navigators obſerve, that even when it was not cold enough to freeze the ſurface of the ſea, it would ſo far chill and infrigidate it, that the ſnow would lie on it without melting.

19. I remember a *Swediſh* extraordinary ambaſſador, and a very knowing perſon, whom I had the honour to be particularly acquainted with, would ſay, when he ſaw a frosty day accompanied with great clearneſs, that it then looked like a *Swediſh* winter ; where, when once the frosty weather is ſettled, the ſky is wont for a very long time to be very ſerene and pleaſant ; and here in *England* we uſually obſerve the ſharpeſt frosty nights to be the cleareſt. But to confirm our obſervation by a very remarkable inſtance, I ſhall borrow it from a navigator very curious of celeſtial obſervations ; which circumſtance I mention to bring the greater credit to the following obſervation of Captain *James*, which in his journal, *pag.* 62. is thus delivered : ‘ The thirtieth and one and thir- ‘ tieth of *January*, there appeared in the be- ‘ ginning of the night more ſtars in the fir- ‘ mament, than ever I had before ſeen by two ‘ thirds. I could ſee the cloud in *Cancer* ‘ full of ſmall ſtars.’

20. To determine what effect the coldneſs of the air may have upon the refractions of the luminaries and other ſtars, I look upon as a work of no ſmall difficulty, and that would require much conſideration as well as time : wherefore I ſhall only add two or three narratives, ſupplied me by navigators, without adding at preſent any thing to the matters of fact.

21. The firſt is that famous obſervation of the *Dutch* in *Nova Zembla*, who take great pains to evince by ſeveral circumſtances, ſome of them highly probable, that they were not miſtaken in their account of time ; according to which, they concluded, that they ſaw the ſun, whom they had loſt ſight of eleven weeks before, about fourteen days ſooner than he ought to have appeared to them : which difference has been, for aught I know to the contrary, by all that have taken notice of it, aſcribed to the ſtrangely great refraction in that gelid and northern air.

22. And as for that other extremely cold country, where Captain *James* wintered, it appears by his journal, that he there made divers celeſtial, and other obſervations, which gave him opportunity to take notice of the refraction ; and he ſeems to complain, that he found it very great, though among the particulars he takes notice of, there are ſome, that ſeem not very ſtrange, nor are there any, that are near ſo wonderful, as that newly mentioned of the Hollanders in *Nova Zembla* ; however in regard of the extreme coldneſs of the winter air in *Charleton Iſland*, it may be worth while to take notice of the following paſſages out of his journal, ſince they may at leaſt help us to conjecture, what is not to be expected in reference to refractions from the coldneſs of the air as ſuch, *page* 61. ‘ The 21ſt of *January* (ſays he) I ob- ‘ ſerved the latitude with what exactneſs I ‘ could (it being very clear ſun-ſhiny weather) ‘ which

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'which I found to be 52 deg. 52 min. This 'difference is by reaſon, that here is a great 'refraction.' Which laſt clauſe is very obſcure, unleſs it refers, as one may gueſs it does, to what he had elſewhere ſaid, that on his firſt coming to the iſland, *pag.* 46. 'he took the 'latitude with two quadrants, and found it 'to be juſt 52 degrees,' without any minutes. Elſewhere, *pag* 64. 'my obſervations (ſays he) 'by theſe glaſſes I compared to the ſtars com-'ing to the meridian.' By this means we found the ſun to riſe twenty minutes before it ſhould, and in the evening to remain above the horizon twenty minutes (or thereabouts) longer than it ſhould. And this by reaſon of the refraction.

AND in another place, *March* the 15th. 'This evening (ſays he) *pag.* 66. the moon 'roſe in a very long oval alongſt the horizon.'

I ſhall add one paſſage more out of our author, concerning refractions, not only becauſe it may bear teſtimony to ſome relations of the like kind, that I have mentioned in another treatiſe; but becauſe it is concluded with an obſervation, that (if there be nothing of miſtake in it) is odd enough. 'I had often (ſays 'he) *pag.* 69. obſerved the difference betwixt 'clear weather and miſty refractious weather 'in this manner. From a little hill, which 'was near adjoining to our houſe, in the clear-'eſt weather, when the ſun ſhone, with all 'the purity of air, that I could conceive, we 'could not ſee a little iſland, which bare off 'us ſouth ſouth-eaſt ſome four leagues off; but 'if the weather were miſty (as aforeſaid) then 'we could often ſee it from the loweſt place.'

23. HITHERTO I have treated of the temperature of air in general; and though the paſt diſcourſe have been prolix enough, yet poſſibly I may have no fewer things to ſay, if I would at preſent fall upon the conſideration of the three regions, into which the air is wont to be diſtinguiſhed. For I confeſs I am not altogether without ſcruples, both as to the number, and as to the limits, and as to the qualities aſſigned to theſe aërial regions. But (as I have partly declared in another * tract) though I had time to enter upon ſo intricate a diſquiſition, yet till I have an opportunity to conſult ſome other papers, I know not, whether what I have noted, touching theſe difficulties, may not more properly belong to another treatiſe, than this of cold.

* *A ſceptical diſquiſition of Antiperiſtaſis.*

24. HAVING thus diſpatched the few experiments I can meet with among my papers, concerning the coldneſs of the air, I now proceed to ſubjoin ſome obſervations, that have occurred to me in the writings or verbal relations of navigators and travellers about that ſubject. But in regard, that the greateſt part of the phænomena of cold, which nature of her own accord preſents us with, ſeem to be produced, either mediately or immediately by the air, we intend not here to treat of the coldneſs of the air in the largeſt ſenſe, but only to take notice of ſome of the choicer inſtances, that ſeem to belong to our preſent argument. And theſe we ſhall annex, either as promiſcuous obſervations at the cloſe of this ſection, or as illuſtrations or proofs of the three following obſervations.

2. THE firſt I ſhall propoſe in theſe terms; 'That the greater or leſſer coldneſs of the 'air, in ſeveral climates and countries, is no-'thing near ſo regularly proportionate to their 'reſpective diſtances from the pole, or their 'vicinity to the equator, as men are wont to 'preſume.'

THIS puts me in mind of what I have formerly, either heard from a ſkilful man, or obſerved my ſelf about the difference betwixt places of the ſame latitude in the northern and ſouthern hemiſphere; namely, that of places equally diſtant, the one from the northern, the other from the ſouthern pole, the latter are generally much colder than the former. And, as I remember, I long ſince noted ſome things to this purpoſe; but being not at preſent able to recover them, I ſhall propoſe this only, as that, which may deſerve an inquiry, being not yet ſatisfied, but that in the examples I had taken notice of, ſome accidental and concurrent cauſes may have occaſioned the greater coldneſs obſerved in the places ſeated on the other ſide of the line; as, on this ſide of it, the like cauſes may much vary the coldneſs of differing places of equal latitudes, as we are now going to ſhew by the following teſtimonies.

1. How exceſſive a cold reigns at *Moſcow* and thereabouts in the winter time, when many men loſe their noſes or their toes, and ſome their lives by the extremity of the cold, we have ſeveral times occaſion to take notice of in this treatiſe. And yet at *Edinburgh*, which I find ſome of our modern navigators to place more northerly by above a degree; there, I ſay, and in the neighbouring places, the air is known to be temperate enough, and the cold very tolerable: and it is affirmed, that the ſnow very rarely lies any long time on the ground after it is fallen.

2. IN the voyage made for diſcoveries northward by Mr. *Pool*, in the year 1610, I find this paſſage, *pag.* 702. 'I was certified, that 'all the ponds and lakes were unfrozen, they 'being freſh water; which putteth me in 'hope of a mild ſummer here, after ſo ſharp 'a beginning, as I have had; and my opini-'on is ſuch (and I aſſure my ſelf it is ſo) 'that a paſſage may be as ſoon attained this 'way by the pole, as any unknown way what-'ſoever, by reaſon the ſun doth give a great 'heat in this climate; and the ice (near the '79th degree) I mean that, that freezeth here, 'is nothing ſo huge as I have ſeen in 73 'degrees.'

To this agrees the teſtimony of the Hollanders in their firſt voyage to *Nova Zembla*, in which the writer of it, *Gerat de Veer*, ſpeaks thus, *pag.* 473, 474. 'We have aſſuredly 'found, that the only and moſt hinderance to 'our voyage was the ice, that we found about '*Nova Zembla*, under 73, 74, 75 and 76 de-'grees, and not ſo much upon the ſea, between 'both the lands; whereby it appeareth, that not 'the nearneſs of the north pole, but the ice, that 'cometh in and out from the Tartarian ſea 'about

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'about *Nova Zembla*, cauſed us to feel the great-
'eſt cold. Therefore in regard, that the nearneſs
'of the pole was not the cauſe of the great cold
'that we felt, *&c.*' And a little after,——'It
'is true (ſays he) that in the country lying un-
'der 80 degrees (which we eſteem to be
'*Greenland*,) there is both leaves and graſs,
'to be ſeen, wherein ſuch beaſts, as feed of
'leaves and graſs, as harts, hinds, and ſuch
'like beaſts, live; whereas to the contrary in
'*Nova Zembla* there groweth neither leaves
'nor graſs, and there are no beaſts there, but
'ſuch as eat fleſh, as bears and foxes, *&c.* al-
'though *Nova Zembla* lieth 4, 5, and 6 de-
'grees more ſoutherly from the pole, than the
'other land aforeſaid.'

And to this purpoſe I remember what is related by the learned *Joſephus Acoſta*, concerning the heats and colds in the torrid zone, and elſewhere: *Acoſta*, *lib.* 2. *cap.* 9. *pag.* 101. 'When I paſſed (ſays he) to the *Indies*, I
'will tell what chanced unto me: having read
'what poets and philoſophers write of the
'burning zone, I perſuaded my ſelf, that com-
'ing to the equinoctial, I ſhould not endure
'the violent heat: but it fell out otherwiſe,
'for when I paſſed, which was when the ſun
'was there for zenith, being entered into
'*Aries*, in the month of *March* I felt ſo great
'a cold, as I was forced to go into the ſun to
'warm me. What could I elſe do then but laugh
'at *Ariſtotle*'s meteors and his philoſophy,
'ſeeing that in that place, and at that ſeaſon,
'whenas all ſhould be ſcorched with heat,
'according to his rules, I and all my compani-
'ons were a-cold? In truth there is no re-
'gion in the world more pleaſant and tem-
'perate than under the equinoctial, although
'it be not in all parts of an equal tempera-
'ture, but have great diverſities. The burn-
'ing zone in ſome parts is very temperate,
'as in *Quito*, and on the plains of *Peru*; in
'ſome parts very cold, as at *Potoſi*; and in
'ſome very hot, as in *Ethiopia*, *Braſil* and
'the *Moluccoes*.' And within two chapters after, he diſcourſes more largely of ſome of theſe particulars. And again chapter the 12th, 'You may continually (ſays he) *pag.* 109.
'ſee upon the tops of theſe mountains ſnow,
'hail, and frozen waters; and the cold ſo bit-
'ter, as the graſs is all withered, ſo as the
'men and beaſts, which paſs that way, are be-
'numbed with cold. This, as I have ſaid,
'is in the burning zone, and it happens moſt
'commonly, when they have the ſun for zenith.'

These teſtimonies of a learned man, that writes upon his own knowledge, I thought worth producing, to make it probable, that as in ſeveral countries the heat does not always anſwer to the nearneſs of places to the line; ſo in northern regions the cold may not always be proportionate to their vicinity to the pole. In Mr. *Hudſon*'s ſecond voyage, written by himſelf, he mentions, that above 71 degrees, though they were much peſtered with ice, about the end of *June*, 'that day (when this
'happened) *Purchas*, *pag.* 578. was calm,
'clear, and hot weather; adding of the next
'day alſo, that it was calm, hot, and fair wea-
'ther.' And *Acoſta* tells us, 'that we ſee
'theſe differences, not only on the land, but
'alſo on the ſea: there are ſome ſeas, where
'they feel great heat, as the report of that of
'*Mazambigus*, and *Ormus* in the Eaſt, and of
'the ſea of *Panama* in the Weſt. There are
'other ſeas in the ſame degree of height very
'cold, as that of *Peru*, in the which we were
'a-cold, when we firſt ſailed it, which was
'in *March*, when the ſun was directly over
'us. In truth, on this continent, where the
'land and ſea are of one ſort, we cannot ima-
'gine any other cauſe of this ſo great a dif-
'ference, but the quality of the wind, that
'doth refreſh them.'

But to multiply no more inſtances, we ſhall conclude with this one, that *Charleton Iſland*, where Captain *James* wintered (and of which we ſo often have occaſion to make mention in our hiſtory) though it ſeems by the effects to be a colder region, than even the country about *Moſcow*, and perhaps as cold as *Nova Zembla* it ſelf; yet Captain *James*, who had ſeveral times occaſion to take the latitude of it, (ſee *James*'s voyage, *pag.* 61, and 81, and elſewhere) aſſigns it the ſame elevation, and conſequently the ſame diſtance from the pole, with *Cambridge*, whoſe latitude he reckons to be 51 degrees beſides minutes, and whoſe air is very well known to be very temperate. And it is remarkable, that though this place, whoſe latitude is ſhort of 52 degrees, was found uninhabitable by reaſon of the cold, (*Purchas*, *pag.* 569.) yet not only in Mr. *Hudſon*'s voyage, the writers admoniſh the readers to take notice, 'That although they ran along
'near the ſhore, they found no great cold,
'which made them think, that if they had
'been on ſhore, the place is temperate.' *Joſephus Acoſta*, *lib.* 2. *pag.* 111, 112. And yet in this place they reckon themſelves to have reached the 78th degree of latitude: and our recenter navigations inform us, that ſeveral parts of *Greenland*, to which this new-ly-mentioned coaſt belonged, are well enough inhabited: and one of our Engliſh navigators aſſures us, that the true height of *Puſtozera* in *Ruſſia* is no leſs than 68 degrees and a half, if not more, and yet that is a town not only well inhabited, but of great trade. But in *Hudſon*'s voyage I find what is more ſtrange, that under the 81ſt degree of latitude, beyond which they diſcovered land very far off, but (beyond which none is thought to have actually ſailed towards the pole) 'they found
'it during the whole day clear weather, with
'little wind, and reaſonably warm.' *Purchas*, *pag.* 571. And beyond 80 degrees, they not only found a ſtream or two of freſh water,
'but found it hot on the ſhore, and drank
'water to cool their thirſt, which they alſo
'commended.'

II. The next obſervable I am to propoſe about the coldneſs of the air, is this; 'That
'the degrees both of heat and cold in the
'air may be much greater in the ſame cli-
'mate, and the ſame place, at ſeveral ſeaſons

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'of the year, or even at ſeveral times of the 'ſame day, than moſt men would believe.'

For the proof of this propoſition, we ſhall ſubjoin two ſorts of teſtimonies, of travellers, and navigators; the former ſhewing, that in countries, where it is very cold in winter, it may nevertheleſs be hot in ſummer; and the latter manifeſting, that even on the ſame day, as well as in the ſame place, the heat and cold, that ſucceeded one another, may be one of them ſenſible, though the other were extreme, or may perhaps be both of them conſiderable.

To make this good, we ſhall produce the following teſtimonies.

1. Dr. *Giles Fletcher*, Engliſh ambaſſador to the *Muſcovian* emperor, in his treatiſe of *Ruſſia*, and the adjoining regions, has this memorable paſſage to our preſent purpoſe: 'The 'whole country (ſays he, *pag.* 414.) differeth 'very much from itſelf, by reaſon of the year; 'ſo that a man would marvel to ſee the great 'alteration and difference betwixt the winters 'and ſummers in *Ruſſia*. The whole country 'in the winter lieth under ſnow, which faileth 'continually, and is ſometime of a yard or 'two thick, but greater towards the north; 'the rivers and other waters are all frozen up, 'a yard or more thick, how ſwift or broad 'ſoever they be; and this continueth com-'monly for five months, to wit, from the 'beginning of *November*, till towards the end 'of *March*; what time the ſnow beginneth to 'melt, ſo that it would breed a froſt in a man 'to look abroad at that time, and ſee the 'winter's face of that country.' And a little after he adds, *Purchas*, 415. 'And yet in 'the ſummer time you ſhall ſee ſuch a new 'hue and face of a country, the woods (which 'for the moſt part are all of fir and birch) 'ſo freſh, and ſo ſweet; the paſtures and mea-'dows ſo green, and well grown (and that 'upon the ſudden) ſuch variety of flowers, 'ſuch noiſe of birds (eſpecially of nightingales, 'that ſeem to be more loud, and of a more 'variable note, than in other countries) that a 'man ſhall not lightly travel in a more plea-'ſant country.' And ſome lines after, 'As 'the winter exceedeth in cold, ſo the ſummer 'inclineth to over-much heat, eſpecially in the 'months of *June*, *July* and *Auguſt*, being 'much warmer than the ſummer air in Eng-'land.'

Voyage d. Moſcovie & de Perſe, livre 3. p. m. 117, 118, 119.

ALMOST like things have been much more recently affirmed by the learned *Olearius*, ſecretary to the Duke of *Holſtein*'s embaſſy into *Ruſſia*, and now *Bibliothecarius* to the preſent Prince of *Holſtein*. And an acquaintance of mine, who, after having lived in *Italy*, paſſed a ſummer in *Ruſſia*, aſſured me, that he ſcarce in *Italy* did ever eat better melons, than ſome, which he had eaten at *Moſcow*, of a ſtrange bigneſs; which bears witneſs to that almoſt incredible relation of *Olearius*, who (after having much praiſed their goodneſs at *Moſcow*) affirms, that he there met with melons of 40 pound weight, of which he there teaches the culture. (*pag.* 119.)

AT the royal city of *China*, *Pequin*, which ſcarce exceeding the 42d degree of latitude, one would expect, that as the ſummer is very warm, ſo the winter ſhould be very mild, as it is obſerved to be in divers places of *Spain*, *Italy* and *Greece*, that have the ſame, or a more northern latitude: and yet the learned Jeſuit *Martinius*, who lived many years in *China*, aſſures us, that uſually for four whole months together all the rivers are ſo hard frozen, that not only all ſhips are cloſed, and kept immovable by the ice, but that alſo horſes, waggons, and even the heavieſt carriages do ſecurely paſs over the ice. Concerning which he adds this ſtrange circumſtance, that it is uſually made in one day, though to its diſſolution it require many.

Proſper Alpinus, in his learned treatiſe *de medicina Ægyptiorum*, *lib.* 1. *cap.* 6. tells us, that at *Grand Cairo*, where he practiſed phyſick, though that famous metropolis of *Ægypt* be diſtant ſix degrees from the tropick of *Cancer*, yet the air, which in ſummer is almoſt inſupportably hot, in winter is ſometimes very conſiderably cold; adding, that there is not any ſort of diſeaſes, that proceed (as he is pleaſed to ſpeak) from diſtillations from the head, to which the people are not there ſubject. To theſe inſtances we ſhall annex but two more, but thoſe remarkable ones.

THE firſt is mentioned by *Purchas*, as communicated to him by an eye-witneſs, in theſe words: 'This I thought good at our parting 'to advertiſe thee, that Mr. *Hebey* hath af-'firmed to me, touching the diverſity of wea-'ther in *Greenland*, that one day it hath been 'ſo cold (the wind blowing out of ſome quar-'ter) that they could ſcarce handle the frozen 'ſails; another day ſo hot, that the pitch melt-'ed of the ſhip, ſo that hardly they could 'keep their cloths from pollution: yea, he 'hath ſeen at midnight tobacco lighted or 'fired by the ſun-beams with a glaſs.' The other example, I am to produce, is no leſs remarkable; namely, that in the often mentioned *Charleton Iſland*, where that winter was as ſharp, perhaps, as any known place of the habitable world, Captain *James* his journal gives us this account of the weather: 'In *June* the 'ſixteenth (ſays he, *pag.* 81.) was wondrous 'hot, with ſome thunder and lightning, ſo 'that our men did go into the ponds aſhore 'to ſwim, and cool themſelves; yet was the 'water very cold ſtill. Here had lately ap-'peared divers ſorts of flies, as butterflies, 'butcher's-flies, horſe-flies, and ſuch an infinite 'abundance of blood-thirſty muſkitoes, that 'we were more tormented with them, than 'ever we were with the cold weather. Theſe '(I think) lie dead in the old rotten wood 'all the winter, and in ſummer they revive 'again. Here be likewiſe infinite companies 'of ants, and frogs in the ponds upon the land.'

THUS we ſee, what difference there may be in the ſame place betwixt the temperature of the air in the winter and ſummer. We ſhall now add, what may appear more ſtrange, that there may be very great diſparities in the heat and coldneſs of the air, not only in the ſame place, but within the compaſs of the ſame day.

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THE lately mentioned *Alpinus* affords me an example to this purpoſe in *Ægypt* it ſelf, where one would expect a much more uniform heat. *Hyeme* (ſays he, pag. 9.) *nocturnus aer admodum frigidus obſervatur, qui oborto ſole paulo poſt parum incaleſcit, in meridieque plurimum; adveniente vere nocte rurſum in frigidum permutatur, ita, at aër ille valdè inæqualis ſit dicendus, ab ipſiuſque illa inæqualitate plurimi morbi originem ducunt atque generatur, qui eo tempore per urbem vagantur.*

THE learned *Olearius* relating how he travelled with the ambaſſadors, whoſe ſecretary he was, over a branch of mount *Taurus*, takes notice, that it being after the middle of *June*, the air of that hot region of *Perſia* obliged them only to travel by night, and yet the nocturnal cold was ſo great, that they were all benumbed with it, inſomuch, that they were hardly able to alight from their horſes; adding, that the ſudden change from an extreme cold to the exceſſive heat, they were again expoſed to the next day, caſt no leſs than 15 of their company into ſtrong burning fevers at once. (Which brought into my mind the complaint of good *Jacob*, who, though he lived in an eaſtern country, when he had ſaid, *that in the day the drought conſumed him*, adds *and the froſt by night.*)

AND the ſame curious traveller mentions, that in another country in *Perſia*, called *Faclu*, notwithſtanding the heat of the region (at the end of *March*, at which time they paſſed that way) they ſaw and felt in one night, which they were forced to paſs without their tents, both lightning, and thunders, and winds, and rain, and ſnow, and ice.

WE will conclude with a remarkable inſtance, afforded us by the journal of the Engliſh, that wintered at *Charleton Iſland*. 'The 'ſeaſon here in this climate (ſays the often 'quoted author of the voyage) is moſt unnatu-'ral; for in the day-time it will be extreme 'hot, yea, not endurable in the ſun; which is, 'by reaſon, that it is a ſandy country. In the 'night again, it will freeze an inch thick in 'the ponds, and in the tubs about, and in our 'houſe, and all this towards the latter end of '*June.*'

III. THE third obſervable I intended to take notice of about the coldneſs of the air, may be comprized in this propoſition, 'That 'in many places the temperature of the air, as 'to cold and heat, ſeems not to depend ſo 'much upon the elevation of the pole, as up-'on the nature and circumſtances of the winds, 'that blow there.'

IT would require a very long diſcourſe to treat in this place of winds in general, and much more to examine the ſeveral cauſes of winds, that are aſſigned by ſeveral authors; and therefore when I have once given this intimation, that divers of theſe opinions may be more eaſily reconciled, than the maintainers of them ſeem to have thought, to the truth, if not to one another; the cauſes, that may produce wind, being ſo various, that many of thoſe propoſed may each of them in ſome caſes be true, though none of them in all caſes be ſufficient: having hinted this, I ſay, it may ſuffice, on this occaſion, to ſubjoin three or four obſervations, to prove and illuſtrate the matter of fact delivered in the propoſition.

AND firſt, it is a known obſervation in theſe parts of the world, that northerly and northeaſterly winds do at all times of the year bring cold along with them, and commonly, if it be winter, froſt. And here in *England* I have ſometimes wondered at the power of the winds, to bring not only ſudden froſts, but ſudden thaws, when the froſt was expected to be ſettled and durable; which yet ſeems to hold commonly, but not without exception. For during one of the conſiderableſt fits of froſt and ſnow, that I have taken notice of in *England*, I remember, that I obſerved (not without ſome wonder) that the wind was many days * ſoutherly; unleſs it may be ſaid, that this ſoutherly wind was but the return of a ſtream of northerly wind, which had blown for many days before, and might by ſome obſtacles, and agents, not here to be inquired after, be made to wheel about, or recoil hither, before it had loſt the greateſt portion of the refrigerating corpuſcles it conſiſted of before.

THE formerly mentioned *Proſper Alpinus* attributes ſtrange things to the northerly wind, that blows in *Egypt*, as to the cooling and refreſhing the air, in ſpite of the violent heats, that would otherwiſe be intolerable. And many in † *Egypt* aſcribe to the *Æteſian* winds that almoſt miraculous ceaſing of the plague at *Grand Cairo*, of which we elſewhere ſpeak. (*Ibid. lib.* 1, *cap.* 6.) *Dominatur autem aër* (ſays he) *ſummè calidus, ipſius cœli, ut dictum eſt, ratione, quod hæc civitas à Tropico Cancri tantum 6. gradibus diſtet. Quâ brevi intercapedine dum ſol ad illum accedit Tropicum, & illorum Zenith ſit propinquior, aër ille valdè incaleſcit, & niſi Æteſiæ venti tunc à ſeptentrione ſpirarent, vehementiſſimus, & qui vix à noſtris perferri poſſit, caloris æſtus ſentiretur.*

Advenæ noſtri iis provenientibus ad ſubterranea loca confugiunt, in quibus morantur, quouſque ille ventorum ardor reſiderit atque ceſſaverit. Conjunxit hæc incommoda Deus optimus cum aliis quibuſdam bonis, nam ubi calidiſſimi illi venti conticuere, ſtatim à ſeptentrione flare alii incipiunt, qui ſubitaneum inflammatis atque laxatis corporibus ſolatium præſtant. Si enim illi diu perſeveraverint, nemo in eâ regione vivere poſſit. Ibid. lib. 1. cap. 7. pag. 11.

WHENCE winds ſhould have this power to change the conſtitution of the air, and eſpecially to bring cold along with them, is not ſo eaſy to be determined. Indeed the other qualities, and even the heat, that is obſervable in winds, may for the moſt part be probably

* The weather was ſhowy and foggy, freezing our rigging, and making every thing ſo ſlippery, that a man can ſcarce ſtand. And all this with the wind ſoutherly, ſays Captain *James*, (*page* 104.) in his journal, the 26th of *Auguſt*.

† *Ab his ventis aërem alteratum, eſſe cauſam, cur peſtis illa diſſolvatur, multi illorum affirmant. Quod etiam non videtur penitus à veritate alienum, quando id multis etiam rationibus nobis perſuaderi poſſit, inprimiſque*, &c. Proſp. Alpin. lib. 1. De medicina Ægypt. cap. 18.

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bably enough derived from the qualities of the places, by which they paſs. Of this we have already given an example or two in the paſſages lately mentioned. And it may be further confirmed by what *Acoſta* ſays, that he himſelf ſaw in ſome part of the *Indies*, (namely, *Joſephus Acoſta, lib. 3. cap. 9.*) 'That the iron gates 'were ſo ruſted and conſumed by a peculiar 'wind, that preſſing the metal between your 'fingers, it would be diſſolved and crumbled, 'as if it had been hay or parched ſtraw.' And this learned traveller, who ſeems to have taken peculiar notice of the winds, affords us, in divers places of his book, ſeveral examples to confirm what we were ſaying, (though he take not the nature of the regions, along which the wind blows, to be alone in all caſes a ſufficient cauſe of their qualities) of which yet we ſhall now mention but theſe two memorable paſſages. *Lib. 3. cap. 2. pag.* 120. 'In a ſmall 'diſtance (ſays he) you ſhall ſee in one wind 'many diverſities. For example, the *Solanus* 'or Eaſtern wind is commonly hot and 'troubleſome in *Spain*; and in *Murcia*, it is 'the coldeſt and healthfulleſt that is, for that it 'paſſeth by the orchards, and that large cham-'pion, which we ſee very freſh. In *Cartha-'gena*, which is not far from thence, the ſame 'wind is troubleſome and unwholſome. The 'Meridional, (which they of the ocean call 'South, and thoſe of the Mediterranean ſea, '*Mezzo Giorno*) commonly is rainy, and boiſte-'rous, and in the ſame city, whereof I ſpeak, 'it is wholeſome and pleaſant.' And in this deſcription of *Peru, lib. 3. cap. 3.* ſpeaking of the South and South-weſt, he affirms, that this wind yet in this region is marvellous pleaſing.

BUT though, as we were ſaying, many other qualities of winds may be deduced from the nature and condition of the places, by which they paſs; and though the heat alſo, which *Proſper Alpinus* (as we lately took notice) attributes to the ſoutherly winds, that blow in *Egypt*, may be probably aſcribed to the heated exhalations and vapours they bring from the ſouthern and parched regions they blow over; yet whence the great coldneſs of northerly and eaſterly winds ſhould come, may be ſcrupled at by many of the modern philoſophers, who, with divers Carteſians, will not admit, that there are any corpuſcles of cold.

AND poſſibly I could, about theſe matters, propoſe ſome other difficulties, not ſo eaſy to be reſolved. But not being now to diſcuſs the hypotheſis about cold, I think it will be more proper in this place, inſtead of entering upon diſputes and ſpeculations, to ſubjoin an experiment, that I made, to give ſome light about this matter.

CONSIDERING then, that I had not met with any trial of the nature of that I am about to mention, and that ſuch a trial might poſſibly prove lucriferous, I cauſed a pretty large pair of ordinary bellows to be kept a good while in the room, where the experiment was to be made, that it might receive the temperature of the air in that chamber: then placing upon a board one of thoſe flat-bottomed weather-glaſſes, that I elſewhere deſcribed to contain a moveable drop of pendulous water, blowing at ſeveral times with intermiſſions upon the bubble or lower end of the weather-glaſs, though the wind blown againſt my hand were, as to ſenſe, very manifeſtly cold, yet it did not cool the air included in the bubble, but rather a little warmed it, as appeared by a ſmall, but ſenſible, aſcenſion of the pendulous drop each time, that, after ſome interpoſed reſt, the lower part of the glaſs was blown upon, which ſeemed to proceed from ſome ſmall alteration towards warmth, that the air received by its ſtay (though ſhort) in the bellows, as ſeemed deducible from hence, that if by cloſely covering the clack, the matter were ſo ordered, that the air, that ſhould come into the bellows, muſt come in all at the noſe: if this noſe being held very near the bubble of the weather-glaſs, the air were, by opening the bellows, ſuddenly drawn in, that ſtream or air of wind coming from a part of the window, where the air was a little cooler than that, which was wont to come out of the bellows, would not, as the other, make the pendulous drop riſe, but rather the contrary.

THIS done, we proceeded to ſhew by experiment, that though a wind were nothing but a ſtream of air, yet in its paſſage it might acquire a conſiderable coldneſs diſtinct from that, which it has by virtue of its motion; though upon the ſcore of that, we ſee, that air moved by a fan, or (as in our newly-mentioned trial) by a pair of bellows, might, to our touch, feel cold; nor did we forbear to expect a good event of our trial, upon the doubt, that may be raiſed, whether there be frigorifick corpuſcles or no. For whatever become of that queſtion, I thought I might expect, that whether or no ice emit corpuſcles, that are univerſally frigorifick, yet the air being, either by them, or upon what account ſoever, highly refrigerated, the corpuſcles, that compoſe this cold air, being moſt of them driven on before it by the wind, that meets them in its way, will, in a ſenſe, prove frigorifick, in regard of a leſs cold body, which they ſhall happen to be blown upon; and accordingly, having provided a ridge-tile inverted, and half filled the cavity, which, looked upwards, with a mixture of ice and ſalt; and having likewiſe put the iron pipe of the bellows upon that mixture, and then covered it with more of the ſame, that ſo the pipe being ſurrounded, as far as conveniently it could be, with ice and ſalt, the air contained in it might thereby be highly refrigerated; I found, that blowing wind out of the bellows upon my hand, that wind felt much more cold than that, which had been before blown upon my hand out of the ſame bellows, before the frigefactive mixture was applied to it. But for fear my ſenſe of feeling ſhould deceive me, I cauſed a weather-glaſs, made after the common manner, but with a more ſlender pipe, to be ſo placed, that the noſe of the bellows (which, together with the tile and ice, was upheld with a frame) lay in a level with the bubble of the thermometer; and then blowing the refrigerated air of the bellows upon the globular

bular part of the glaſs, I ſaw the water in the cylindrical part and ſhank manifeſtly aſcend, as it was wont to do upon the refrigeration of the included air: and as this aſcenſion of the liquor continued, during three or four blaſts of the bellows, ſo, upon the ceſſation of the artificial wind, the water ſubſided by degrees again, till by freſh blaſts it was made to aſcend. Laſtly, having repeated this experiment, we thought fit to try, how much the air, refrigerated immediately by the frigorifick mixture, would produce a colder wind than the former; and accordingly drawing back the noſe of the bellows, that the air, that ſhould be blown out, might paſs along the cavity left in the frigorifick mixture by the iron pipe (of the bellows) which we had withdrawn, the wind was manifeſtly more cold than before, and had a greater operation on the weather-glaſs, it was blown upon.

THIS experiment, if carried on, and proſecuted, may poſſibly prove more luciferous; but I will not take upon me here to determine, whether all cold winds muſt neceſſarily be made ſo by frigorifick corpuſcles properly ſo called; ſince I have ſometimes ſuſpected, that ſome winds may be cold, only by conſiſting of, or driving before them thoſe higher parts of the air, that, by reaſon of the languid reflection of the ſun-beams, in that upper, (or perhaps arctick) region of the air, are for the moſt part very cold. For it may be obſerved, that rains oftentimes very much and ſuddenly refrigerate the lower air, when no wind, but what the clouds and rain make, accompanies them, as if they brought down ſtore of cold air with them from that upper region; which *Acoſta*, and one I converſed with, that viſited far higher mountains than the *Alps*, affirm to be in ſome places (for I am not ſatisfied, that it is ſo every where) exceeding cold, both in hot climates, and in hot ſeaſons of the year. And I obſerve that the Hollanders do, in more places than one or two, mention the northerly and north-eaſterly winds, to be thoſe, that brought them the prodigious colds they met with, though in *Nova Zembla*, where they were expoſed to them, be ſo northwards, that it lies within 16 or 17 degrees of the pole itſelf. This being a bare ſuſpicion, it may ſuffice to have touched it. But I ſhall ſubjoin two or three inſtances on the occaſion of our propoſition, concerning the influence of the winds upon the air, and to ſhew more particularly, that even cold winds receive not always their qualities ſo much from the quarter, whence they blow, as from the regions, over which they blow: I ſhall therefore begin with what is delivered by Mr. *Wood*, in his *New England*'s Proſpect, *part* I. *chap.* 2. 'Whereas in *England* (ſays he) moſt of the cold winds and 'weathers come from the ſea, and thoſe 'ſituations are counted moſt unwholeſome, 'that are near the ſea-coaſt; in that country 'it is not ſo, but otherwiſe.' And having added, as his reaſon, that the 'north-eaſt wind, 'coming from the ſea, produces warm weather, melting the ſnow, and thawing the 'ground;' he ſubjoins, 'only the North-weſt 'wind coming over the land, is the cauſe of 'extreme cold weather, being always accompanied with deep ſnows, and bitter froſts, '&c.' To which paſſages we ſhall add only one out of Captain *James*, as being conſiderable to our preſent purpoſe. Captain *James*'s voyage, *page* 52, 53. 'The winds (ſays he) 'ſince we came hither, have been very variable and unconſtant; and till within this 'fortnight, the ſoutherly wind was coldeſt. 'The reaſon I conceive to be, for that it did 'blow from the main land, which was all 'covered with ſnow, and for that the North 'winds came out of the great bay, which hitherto was open.'

TITLE XIX.

Of the ſtrange effects of Cold.

1. TO enumerate and proſecute all the ſeveral effects of cold, being the chief work of the whole book, it is not to be expected, that they ſhould be particularly treated of in this one ſection of it, wherein I ſhall therefore confine myſelf to mention only thoſe effects of cold, that are not familiar, but ſeem to have in them ſomething of wonderful; nor muſt I take notice of all them neither, leſt I ſhould be guilty of uſeleſs repetitions, but only of them, which either are not at all, or are but incidentally or tranſiently delivered in the foregoing ſections. Nor is it to be expected, that I ſhould pawn my credit for the truth of every one of the relations I am about to ſubjoin. For if they had not ſomething of extraordinary, and, conſequently, that may beget ſome diffidence in wary men, they would not be proper for the title of this ſection; and moſt of them, that they may be fit to be placed here, muſt be the effects of ſuch extreme degrees of cold, that I cannot, in this temperate climate of ours, examine the truth of them by my own trials: ſo that all I can do, is to make choice of ſuch relations, as are almoſt all of them delivered by the relators, as upon their own knowledge. And even this may perchance not only gratify and excite the curioſity of ſome, who are pleaſed with no things ſo much, as with thoſe, that have ſomewhat in them of prodigy; and (which is more conſiderable) their narratives may afford the ingenious ſuch ſtrange phænomena, that the explication of them may ſerve both to exerciſe their wits, and try their hypotheſis.

2. IT ſeems not neceſſary, in the marſhaling theſe obſervations, to be ſcrupulous about method; but yet to avoid confuſion, we ſhall firſt mention the effects of cold, as to thoſe four great bodies of that part of the ſublunary world we live in, that are commonly reputed elements; and thence we will proceed to take notice of the effects of cold upon ſome other inanimate bodies, and, for an inſtance of its operation on living creatures, upon men.

3. OF the power of cold, either to ſtraighten the ſphere of activity of fire, or to hinder its wonted effects, the chief examples I have met with are recorded, partly by the *Dutch* in *Nova Zembla*, and partly by Captain *James*, when he

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Purchas, lib. 3, cap. 5. sect 2. pag. 495.

wintered in *Charleton Iſland*. Theſe Hollanders in one place ſpeak thus; 'The twentieth it was fair and ſtill weather, the wind 'eaſterly, then we waſhed our ſheets, but it 'was ſo cold, that when we had waſhed and 'rung them, they preſently froze ſo ſtiff, that 'although we laid them by a great fire, the 'ſide that laid next the fire thawed, but the 'other ſide was hard frozen, *&c.*' Elſewhere thus: 'We were in great fear, that if the 'extremity of the cold grew to be more and 'more, we ſhould all die there with cold; 'for what fire ſoever we made, it would not 'warm us.' And becauſe it were tedious to tranſcribe all, that their journals afford us to our preſent purpoſe, we will conclude with this paſſage: 'Hereby we were ſo faſt ſhut 'up into the houſe, as if we had been priſoners; and it was ſo extreme cold, that the fire 'almoſt caſt no heat, for as we put our face to 'the fire, we burnt our hoſe before we could 'feel the heat, ſo that we had work enough 'to do to patch our hoſe; and, which is more, 'if we had not ſooner ſmelt than felt them, we 'ſhould have burnt them ere we had known 'it.' Though Captain *James* wintered in a country many degrees remoter from the pole, than *Nova Zembla*, yet in one place he gives us this account of the cold's power to reſtrain or oppoſe the action of fire: (Captain *James p.* 65.) 'The cook's tubs, wherein he did water 'his meat, ſtanding about a yard from the 'fire, and which he did all day ply with melted ſnow water, yet in the night ſeaſon, 'while he ſlept but one watch, would they be 'firm frozen to the very bottom. And therefore was he fain to water his meat in a braſs 'kettle, cloſe adjoining to the fire; and I have 'many times both ſeen and felt, by putting 'my hand into it, that ſide, which was next 'the fire, was very warm, and the other an 'inch frozen. I leave the reſt to our cook, 'who will almoſt ſpeak miracles of the cold.'

THUS far our Engliſh navigator, whoſe relation, compared with thoſe of the Hollanders, makes me not ſo much wonder, as I once did, that men ſhould relate to *Marcus Polus*, that there is a certain plain in *Tartary*, ſituated between ſome of the higheſt mountains in the world, 'where, if fire be kindled, it is not ſo 'bright, nor ſo effectual to boil any thing, 'as in other places.' (*Purchas, lib.* 1. *cap.* 4. *pag.* 74.) For ſo *Purchas* renders that paſſage; whence occaſion has been taken to impute to *Marcus Polus*, a writer not always half ſo fabulous, as many think him, that he affirmed, that there was a country in *Tartary*, where fire could not be kindled.

4. AND as for the other newly mentioned relations of ſeamen and travellers, though to us, that live in *England*, they cannot but ſeem very ſtrange; yet I am kept from rejecting them as utterly incredible, by conſidering, that ice and ſnow having before their congelation been water, muſt in probability owe their coldneſs to that which reigned in the air: ſo that if in any place nature has, either ſo plentifully ſtocked the air itſelf with frigorifick expirations, or other corpuſcles (if we will admit any ſuch) or have upon any other account rendered it as cold, as it can make ice and ſnow to be, even here amongſt us; I know not, why the northerneſs of the climate, and perhaps ſome ſaline expirations from the earth and ſea, may not there diffuſe through the air a cold ſuperior to that, which by ſmall quantities of ice (or ſnow) and ſalt can at a ſmall diſtance be produced here. And this cold is ſo intenſe, that by pouring ſome water on a joint-ſtool, and placing on it a ſilver tankard, or other convenient veſſel, we may, as experience has aſſured me, with beaten ice (or ſnow) and ſalt, and a little water (which is added to haſten the ſolution of the other) nimbly ſtirred together in the pot, make the mixture freeze the external water quite through the tankard; and they may be by this way ſo hard frozen together, as that by lifting up the pot, you may lift up the joint-ſtool too, and that (which is the circumſtance, for which I mention this) juſt by the fire, which in this caſe is unable to hinder ſo difficult an operation of the cold.

5. THUS much of the effects of cold, in reference to fire. What the ſame quality may perform upon air, we ſhall ſay but little of in this place, becauſe we treat of thoſe phænomena, partly in the foregoing ſection of the coldneſs of the air, and partly in other places. Only we ſhall not here pretermit a teſtimony of the learned *Olearius*, who, as an eye-witneſs, confirms what we elſewhere deliver of the high degree of cold, to which the air may be brought. For he tells us, 'That in *Moſcovy* he experimentally found that, which 'others left recorded in their writings, that 'one's ſpittle would be congealed before it 'reached the ground, and that water would 'freeze as it was dropping down.' (*Olear. lib. 3. p. m.* 117.)

6. OF the effects of cold upon water, we ſhall not need to ſay much in this place, ſince the two notableſt of them being the power cold has to congeal water ſuddenly, and the force it has to turn vaſt quantities of it into ſolid ice; of the former I have newly given, out of *Olearius*, an example as eminent as almoſt any, that is to be met with; and of the latter alſo I have given ſeveral inſtances, in the ſection, that treats of ice: yet two or three notable inſtances, which we do not elſewhere mention, it will not be improper to deliver in this place.

7. THE firſt declares, that notwithſtanding the warmth of the inſide of a man's mouth, his ſpittle may be frozen even there. 'The '27th of *September* (they are the words of '*Gerat de Veer*) it blew hard north-eaſt, and it 'froze ſo hard, that as we put a nail into our 'mouths (as when men work carpenter's 'work, they uſe to do) there would ice hang 'thereon, when we took it out again, and 'made the blood follow.' (*Purchas, pag.* 461.) The like relation (if I miſremember not) I have met with in a modern Engliſh navigator; and it is very little, if at all more ſtrange, than what is affirmed by Queen *Elizabeth*'s ambaſſador to the *Ruſſian* emperor: 'In the extre-'mity of winter (ſays Doctor *Fletcher*, ſpeak-

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'ing of *Muſcovia*) if you hold a pewter diſh 'or pot in your hand, or any other metal, 'except in ſome chamber, where their warm 'ſtoves be, your fingers will ſtick faſt to it, 'and draw off the ſkin at the parting.'

8. THE other inſtance, I intend to mention, is this, that though *Macrobius*, and other learned men both ancient and modern, will not allow ſalt water to be congealable; yet the *Dutch* at *Nova Zembla* relate even in the midſt of *September* (and as the marginal note ſays, in a night) 'it froze two inches thick 'in the ſalt water.' (*Purchas*, *pag.* 491.)

9. AS to the effects of violent colds upon the earth, what they would prove upon pure elementary earth (if any ſuch there be) I can but conjecture; but as for that impure or mingled earth, which we commonly read on, the effects of extreme cold upon that may be very notable. For *Olearius* relates, 'that 'in the year 1634, the cold was ſo bitter at '*Moſcow*, that in the great market-place he 'ſaw the ground opened by it ſo, that there 'was made a cleft of many yards long, and 'a foot broad.' [And the preſent great duke of *Muſcovy*'s phyſician being aſked by me concerning the truth of ſuch relations, anſwered me, that he himſelf had in thoſe parts ſeen the ground reduced by the cold, to gape ſo wide, that a child's head might well have been put into the cleft.]

10. IT is ſomewhat ſtrange, that the violent heat of ſummer, and the extreme cold of winter ſhould both of them be able to produce in the ground the like effects: but whether to make theſe gaping chinks, that we have been ſpeaking of, the ſurface of the ground expoſed to the air, being firſt frozen, is afterwards broken by the expanſive force of the moiſt earth underneath, to which the cold at length pierces, and congealing it, makes it ſwell, and heave, and ſo burſt or cleave the hard and frozen cruſt of the ground, which cannot ſufficiently yield to it; whether this (I ſay) may produce the clefts we were ſpeaking of, or whether they muſt be derived from ſome other cauſe, not having yet made the experiments I thought upon, to clear the matter one way or other, I do not as yet pretend to determine, but will rather ſubjoin the ſecond obſervation, I purpoſed to mention, of a ſtrange operation of cold upon the ground; and it is afforded us by the *Dutch*, in their often quoted third voyage to *Nova Zembla*; in one place of which they tell us, 'That when they had 'built them a wooden houſe, and were going 'to ſhut themſelves up in it for the winter, 'they made a great fire, without the houſe, 'therewith to thaw the ground, that they 'might ſo lay it, *viz.* the wood, about the 'houſe, that it might be the cloſer; but it 'was all loſt labour, for the earth was ſo hard, 'and frozen ſo deep into the ground, that 'they could not thaw it, and it would have 'coſt them too much wood, and therefore 'they were forced to leave off that labour.'

11. AFTER what we have ſaid about the ſtrange effects of cold, in reference to fire, air, water, and earth, we will now proceed to take notice of its effects upon confeſſedly compounded bodies, whether inanimate or living: but of the former ſort of mixed bodies (I mean thoſe, that have not life) it will not be neceſſary to ſay much in this ſection, in regard that we have in many other places, upon ſeveral occaſions, had opportunities to mention already moſt of the particulars, that belong to that head. For we elſewhere take notice, that violent colds would freeze beer, ale, vinegar, oil, common wine, and even ſack, and *Alicant* themſelves. We have likewiſe noted, that the cold may have a notable operation upon wood, bricks, ſtone, veſſels of glaſs, earth, and even pewter, and iron themſelves; to which *Bartholinus*, out of *Janus Munck*'s voyage to *Greenland*, allows us to add veſſels of braſs (though theſe are not immediately broken by the cold, but by the included liquors, which it dilates;) and divers ſtrange effects of cold upon inanimate bodies, which it were here troubleſome to recapitulate, may be met with diſperſed in ſeveral places of the preſent hiſtory. Wherefore having only intimated in general, that, though many plants are preſerved by a moderate cold, yet it has been obſerved, that moſt garden-plants are deſtroyed by exceſſive degrees of it, we will paſs on to conſider the effects of cold upon animals: of the many obſervations, that we have met with among travellers, concerning this ſubject, we ſhall, to avoid prolixity, deliver only the conſiderableſt, and thoſe, that we find atteſted by very credible writers.

12. Captain *James*, ſpeaking of the laſt of the three differences he makes of cold (namely, that, which he and his company felt in the woods) gives this account of it; (Captain *James*'s voyage, *p.* 64.) 'As for the laſt, it 'would be ſo extreme, that it was not endu-'rable; no clothes were proof againſt it, no 'motion could reſiſt it. It would moreover 'ſo freeze the hair of our eye-lids, that 'we could not ſee; and I verily believe, 'that it would have ſtifled a man in a very 'few hours.'

13. *Olearius* giving an account of the air of *Muſcovy*, and eſpecially the capital city of it, 'The cold (ſays he, *Livre* 3. *p. m.* 117.) 'is there ſo violent, that no furs can hinder 'it, but ſometimes men's noſes and ears, 'feet and hands will be frozen, and all fall 'off.' He adds, that in the year 1634, when he was there, 'they could not go 50 paces 'without being benumbed with cold, and in 'danger of loſing ſome of their limbs.' And yet to add that remarkable obſervation upon the by, the ſame author, near the ſame place, ſpeaking of *Moſcow*, and the neighbouring provinces diſtinguiſhed from the reſt of that vaſt empire, ſays, (*Livre* 3. 116.) 'that the 'air is good and healthy, ſo that there one 'ſcarce ever hears of the plague, or any other 'epidemical diſeaſes.' And he adds, that for that reaſon, when in the year 1654, 'the 'plague made havock in that great city, 'the thing was very ſurprizing, nothing like 'it having been ſeen there in the memory 'of man.'

14. OUR

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14. OUR already divers times mentioned, Engliſh ambaſſador Dr. *Fletcher*, ſpeaking of the cold, that ſometimes happens in *Ruſſia*, witneſſeth thus much of it: 'Divers (ſays he, 'Purchas, *lib.* 3. *pag.* 415.) not only that 'travel abroad, but in the very markets and 'ſtreets of their towns, are mortally pinched, 'and killed withal; ſo that you ſhall ſee 'many drop down in the ſtreets, many tra- 'vellers brought into the towns, ſitting dead 'and ſtiff in their ſleds. Divers loſe their noſes, 'the tips of their ears, and the balls of their 'cheeks, their toes, feet, *&c.* Many times 'when the winter is very hard and extreme, 'the bears and wolves iſſue by troops out 'of the woods, driven by hunger, and enter 'the villages, tearing and ravening all they 'can find, ſo that the inhabitants are fain to 'flee for the ſafeguard of their lives.'

15. To deſcend now to obſervations, that do ſomewhat more punctually ſet forth the more particular phænomena of cold, in reference to men's bodies, take the following obſervation: 'The 15th of *March* ſome of their 'men, that had been abroad to kill deer, 'returned ſo diſabled with cold, which did riſe 'up in bliſters under the ſoles of their feet, 'and upon their legs, to the bigneſs of wal- 'nuts, that they could not recover their 'former eſtate (which was not very well) in a 'fortnight after.' This may be confirmed by that paſſage of the Hollanders, where ſpeaking of their preparing ſpringes to take foxes, they add, (*Purchas*, *pag.* 497.) that 'they 'did it with no ſmall trouble; for that if 'they ſtayed long without doors, there aroſe 'bliſters upon their faces and ears. We did 'daily find by experience (ſays Captain *James*, 'page 64.) that the cold in the woods would 'freeze our faces, or any part of our fleſh, that 'was bare; but it was not ſo mortifying, *&c.*'

16. THE Dutch, ſpeaking of the pains they were fain to take to dig away the ſnow, that covered the houſe, and choaked up their doors, adds, (*page* 497.) that in that laborious work, 'they were forced to uſe great ſpeed, 'for they could not long endure without the 'houſe, becauſe of the extreme cold, although 'they wore foxes ſkins about their heads, and 'double apparel upon their backs.'

17. THE lately mentioned Captain *James* relates, that in *Charleton* Iſland he was fain to cut the hair of his head ſhort, and ſhave away all the hair of his face, becauſe the icicles, that would be faſtned to it, made it, (as he ſpeaks, *page* 56.) become intolerable.

18. AND he elſewhere relates, that once he and his companions, having been for a little while parted into two companies, 'had their 'faces, hair, and clothes ſo frozen over, that 'they could not know each other by their ha- 'bits, nor (which is a conſiderable circum- 'ſtance, for whoſe ſake chiefly I mention this paſſage) 'by their voices.' *Page* 52.

19. AND the ſame author gives this account of the death of the gunner of his ſhip, whom he calls a ſtrong-hearted man, and who died before the end of *November*. 'He had (ſays our author) 'a cloſe boarded cabin in the gun-room, which 'was very cloſe indeed, and as many clothes 'on him as was convenient, (for we wanted no 'clothes) and a pan with coals of fire con- 'tinually in his cabin; for all which warmth, 'his plaiſter would freeze at his wound, and 'his bottle of ſack at his head.'

20. 'THE 11th of *December* (ſays *Gerat de* Purchas, 'Veer) it was fair weather, and a clear air, *lib.* 3. *cap.* 'but very cold, which he that felt not would 5. *pag.* 496. 'not believe; for our ſhoes froze as hard as 'horns upon our feet, and within they were 'white, ſo that we could not wear our ſhoes, 'but were forced to make great pattens, the 'upper part being ſheeps-ſkins, which we 'put on over three or four pair of ſocks, and 'ſo went in them to keep our feet warm; yea, 'and the clothes upon our backs were white 'over with froſt.'

21. WHICH may be ſomewhat confirmed by this paſſage of Captain *James*: 'The clothes Page 65. 'on our beds would be covered with hoar 'froſt, which in this little habitacle was not far 'from the fire.' We might add to all theſe this other paſſage of the often-mentioned *Gerat de Veer*: 'The 26th of *December*, it was foul Purchas, 'weather, the wind north-weſt, and it was page 49. 'ſo cold, that we could not warm us, although 'we uſed all the means we could with great 'fires, good ſtore of clothes, and with hot 'ſtones and billets laid upon our feet, and upon 'our bodies, as we lay in our cabins; but 'notwithſtanding all this, in the morning our 'cabins were frozen, *&c.*' But we ſhall not inſiſt on ſuch paſſages as this laſt recited, becauſe that of the force of cold to repreſs and withſtand the fire we have already delivered as remarkable things, as will be eaſily met with, in approved writers, in the former part of this preſent ſection.

22. I HAVE myſelf met with a knowing and very credible perſon, that related to me of the cold of *Ruſſia*, where he travelled, little leſs ſtrange things, than thoſe I have mentioned out of books; and if I did not want the hiſtorian's name, I ſhould make ſmall difficulty to add, that ſince I made a good progreſs in this preſent ſection, a very learned traveller (though not into cold countries) related to me, upon the occaſion of what I was treating, what he affirmed to have met with in an approved hiſtory of the ſtrange operation of the inclemency of the air upon multitudes of men at once; namely, that about the year (if he rightly remember it) 1498, an army of the Turks making an incurſion into *Poland*, upon their return was ſurpriſed with ſuch an extremity of cold and of ſnow, that though it were but (if he miſtake not) in *November*, forty thouſand of them (the whole army conſiſting of ſeventy thouſand) periſhed through the extremity upon the place.

23. AMONGST the many relations I have met with of the fatal effects of cold in the northern countries, I took notice, not without a little wonder, as well as trouble, that I could not find, that any of the relators had the curioſity to ſee, what change was made in the internal parts of the bodies ſo deſtroyed, which yet were an inquiry very proper to have been made;

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made; but at length the other day an ingenious perſon having ſhewed me a book newly publiſhed in French, containing the deſcription of a Polonian province he calls *Ukrain*, as I was ſkimming it over, with hopes to find ſome obſervations about cold, I lighted on a relation, which, though not ſuch as I deſired, is more than I have any where elſe found; and I take the more notice of it, becauſe that though the very name of this province is ſcarce hitherto known to us in *England*, yet having a while after, by good chance, met with an intelligent Polonian lord, and having enquired of him, whether he had ever been in that country, he both told me, that he had been quartered there, and by his anſwers and relations did countenance divers particulars of it, mentioned by this French officer (named *Monſieur de Beauplan*) who lived long there. This author then, after having taken notice, that this fertile province, though but ſituated in the ſame height of the pole with *Normandy*, is oftentimes ſubject to exceſſive colds, (which circumſtance I mention as a further confirmation of ſomething of the ſame nature delivered in the former ſection) gives an account of two differing effects of this cold upon the bodies of men; the one being a peculiar kind of ſickneſs, the other death.

24. The firſt, which I remember not to have elſewhere met with, is, that ſometimes, when the natural heat proves ſtrong enough to protect the toes, and cheeks, and ears, and other parts, that are either more remote from the heart, or more tender, from a ſudden mortification; yet unleſs nature be aſſiſted, either by good precautions, or remedies, ſhe cannot hinder the cold from producing in theſe parts cancers, as painful as thoſe, which are cauſed by a ſcalding and malignant humour; and which let me ſee (ſays my author) when I was in thoſe countries, that cold was not leſs cutting nor powerful to deſtroy things, than the fire to conſume them. He adds, that the beginning of theſe cancerous ſores is ſo ſmall, that what produces the pain ſcarce equals the bigneſs of a pea, and yet in few days, nay ſometimes in few hours, it ſpreads ſo, as to deſtroy the whole part it invades; which he confirms by the example of two perſons of his acquaintance, who in a trice loſt by congelation the badges of their ſex.

25. As to thoſe, that are killed with cold, our author informs us, that they periſhed by two differing kinds of death. For ſome being not ſufficiently fortified againſt the cold by their own internal heat, not competently armed againſt it by furs, inunctions, and other external means, after having had their hands and feet firſt ſeized by the cold, till they grow paſt feeling it there, the reſt of their bodies are ſo invaded, that they are taken with a (kind of lethargick) drowſineſs, that gives them extreme propenſity to ſleep; which if indulged to, they can no more awake out of, but die inſenſibly. And from this kind of death our author adds, that he was ſeveral times ſnatched by his ſervants, who were more accuſtomed to the cold, and ſeaſonably forced him to awake out of thoſe drowſineſſes, which they knew to be moſt dangerous. And that ſometimes the death by cold is indolent enough, the relations of ſome intelligent acquaintance of mine, who have been in exceeding cold countries, do confirm.

26. But the other way, whereby cold deſtroys men, is that, which is the moſt remarkable in our author, and though leſs ſudden is more cruel. For he tells us, that ſometimes the cold ſeize men's bodies in the reins, and all about the waiſt (and eſpecially horſemen underneath the armour of the back and breaſt) and ſtraightens, as he ſpeaks, thoſe parts ſo forcibly, that it freezes all the parts of the belly, eſpecially the guts; ſo that though they have keen appetites, they cannot digeſt, or ſo much as retain the lighteſt and eaſieſt aliments, without excepting broths themſelves, but preſently reject them by vomit, with unſpeakable gripings and pains, and ſo continually complaining of their condition, and ſometimes crying out, as if ſomebody were tearing out their bowels, they end their miſerable lives, being often brought, by the violence of their torments, to the brink of madneſs and deſpair, before they come to that of the grave. And our author having ſeen ſome of theſe departed wretches opened, ſays, that they found the greateſt part of their guts black, burnt up, and as it were glewed together; whence he thinks it probable, that, as their bowels came to be ſpoiled and gangrenated, they were forced to thoſe complaints and exclamations; and we may add, that probably upon the ſame cauſe depended thoſe continual vomits of what they eat or drank, the gangrene of the guts hindring the deſcent of excrements downwards, as it often falls out in the true *Iliaca Paſſio*, and the periſtaltick, or the uſual motion of the parts being inverted, as it alſo frequently happens in the ſame diſeaſe. There is no doubt but anatomiſts and phyſicians will think this account very imperfect, but yet I thnik myſelf beholden to the author for it, becauſe it is not the beſt, but the only, that I have hitherto yet met with of this matter; though I could wiſh it had been much more full and particular, and that he had alſo opened thoſe animals, and eſpecially their brains, that he mentions to have been killed ſuddenly, and without pain, by cold. For ſuch informations (whoſe want, as far as our climate will permit, I have had thoughts of ſupplying upon experiments of other animals) would perhaps ſatisfy me one way or other about a conjecture I have had, and been able to countenance by ſeveral trials upon vegetables and dead animals, about the cauſe of mortifications produced by exceſſive cold.

27. What effects a violent cold may have upon the bodies of other animals than men, I ſcarce find at all taken notice by the writers I have met with, and what I remember upon that ſubject amounts to but few particulars: the French author lately quoted takes notice in general, that the cold in *Ukrain*, as the Polanders call it, is ſometimes ſo great, as to be ſcarce ſupportable by horſes, and ſome other tame beaſts.

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28. THIS ſame author alſo mentions a certain four footed-animal called *boback*, which is ſaid to be peculiar to thoſe parts, and hides himſelf under ground in the winter: and having inquired of the lately mentioned Poliſh nobleman concerning this beaſt, he told me, that being in that province he had one preſented him as a rarity, upon an occaſion proper enough to be mentioned here. For ſome of the *Poles* chancing to dig (for ſome purpoſe that I remember not) in a certain retired place, were ſurprized to find under ground an animal not familiar to them; and though this creature was ſo frozen and ſtiff, that they thought it to be ſtark dead, yet when they came to flea it for its ſkin, being awakened by pain, it recovered life again, and was brought as a rarity to the commander, from whom I have the relation.

29. THAT ſome other animals may be frozen till they are ſtiff, and yet recover, I ſhall (ere long) have occaſion to obſerve at the cloſe of the 21ſt ſection. And therefore I ſhall now add but this, that whereas it is a tradition among travellers into northern climates, that both birds and wild beaſts are in icy and ſnowy countries ordinarily turned white, if not at all times, yet at leaſt in the winter by the coldneſs of thoſe gelid climates; I dare neither admit the poſition, as a thing that is true univerſally, nor reject it as a thing that is never ſo. For not now to enquire, whether whiteneſs proceeds from the coldneſs of the country, or from ſome ſettled ſeminary impreſſion, or from the imagination of the females affected by the vivid whiteneſs of the ſnow, that almoſt all the year long is the conſtant object of their ſight; I find by the voyages I have peruſed, that navigators often mention their meeting with ſtore of white bears and foxes in *Nova Zembla*, and other very northern regions, as alſo their meeting ſometimes with herds of white deer. And in the *Alps*, always covered with ſnow, good authors mention their having met with white partridges; to which purpoſe I remember, that when I was in *Savoy*, and the neighbouring countries, which have mountains almoſt perpetually capp'd with ſnow, I heard them often talk of a certain white kind of pheaſants to be met with in the upper parts of the mountains, which for the excellency of their taſte were accounted very great delicacies. But on the other ſide, the ſame navigators treating even of the coldeſt climates, ſeem to diſtinguiſh the white bears from others of thoſe parts*; and as for a herd of white deer, their colour may proceed from ſeminal impreſſions, ſince here in *England* I have ſeen ſeveral deer of that colour; and though *Greenland* be by ſome degrees nearer to the pole than *Nova Zembla*, yet I have ſeen a live deer brought thence ſomewhat differingly ſhaped from ours, whoſe ſkin was not white, but rather a kind of dun: and to add that upon the by, I took notice, that provident nature, to arm them againſt the cold, had afforded him a coat, that might have paſſed for a fur.

30. Yet theſe two things ſeem remarkable in favour of the efficacy of cold; the one, that in ſeveral cold countries, as particularly *Greenland*, and *Livonia*, even modern deſcribers of them affirm †, that hares will grow white in winter, and return to their native colour in ſummer; and the other, that though *Charleton Iſland* differ not one degree in latitude from *London*, yet (as the cold is there prodigious, ſo) I remember, that Captain *James* ſomewhere takes notice of his having ſeen there, both divers foxes, that were pied black and white, and white partridges, though he could not catch them. (*Pag.* 46, and *pag.* 89.) But of the whiteneſs of animals I elſewhere treat among other ſubjects, that belong to the hiſtory of colours. And having already been more prolix than I intended in ſetting down the obſervations of others, I think it now time for me to reſume the mention of my own experiments, divers of which, though made before others, that have been already mentioned, X or XII ſections off, I thought fit to reſerve for this place, both for other reaſons, and becauſe this place ſeems proper for experiments, that have a nearer tendency to the hinting or the examining the more general hypotheſis about cold.

TITLE XX.

Experiments touching the weight of bodies frozen and unfrozen.

1. SINCE divers of thoſe ingenious men, that have of late revived and embraced the doctrine of the old Atomiſts, teach us, that water is turned into ice by the introduction of frigorifick corpuſcles, which *Democritus* of old is ſaid to have believed to be cubical (and to which other philoſophers of late have aſſigned other ſhapes indeed, but yet determinate ones) we thought fit, not ſo much for our own ſatisfaction, as for that of others, to try, whether or no a liquor by its increaſe of weight, when frozen, would betray any ſubſtantial acceſſion of the corpuſcles of cold, which, according to the Epicurean principles, may, by reaſon of their ſmallneſs, paſs in freely, and in vaſt multitudes, at the pores of other bodies, and even of glaſs; and which, by reaſon of the ſame ſmallneſs, muſt be ſuppoſed exceedingly numerous to be able to arreſt the motions of ſuch multitudes of minute corpuſcles, as muſt go to the making up of any conſiderable quantity of water.

2. AND firſt we made a trial with eggs, of which our notes give us the following account.

3. [WE took a good pair of ſcales and placing them upon a frame (purpoſely made for ſuch experiments, as required, that the things to be weighed ſhould remain long in the ballance) we put into one of theſe a couple of eggs, and having counterpoiſed them with braſs weights, we ſuffered them to continue all night in a turret (built as it had been made for an obſervatory) that the breaking of the eggs, or any ſuch other accidents might not hinder the

* And it is from very northern countries, that we uſually receive very dark coloured furs, and the skins as well of black foxes as of white ones.

† *Lepores coloris & pellis mutatione anni tempeſtates ſequuntur, ac hiberno tempore albis pilis veſtiti, æſtivis menſibus eoſdem cinereos habent.* Livoniæ nova deſcriptio, pag. 303.

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the ſucceſs of our endeavours, (which were to try, whether the corpuſcles of cold, which divers philoſophers ſuppoſe to be the efficients of congelation, would make them any whit heavier :) but we were ſomewhat ſurprized, when the next morning, after a very ſharp night, going up to the turret, we found (the ſcales and frame being in good plight) the eggs to be grown lighter by near four grains.]

THUS far the note.

4. But though we afterwards repeated the experiment once or twice (if not oftener) yet having been, by intervening avocations, diverted from regiſtering the circumſtances of the events, I dare not now truſt my memory for any more, than that ſome of the circumſtances ſeemed odd enough, but uncertain, and that I deſiſted from proſecuting the experiment, chiefly for this reaſon, that an increaſe of weight in expoſed eggs was ſcarcely to be hoped for, becauſe it ſeemed probable, that part of the more ſubtile and ſpirituous corpuſcles contained in the egg do continually, by little and little, get away through the pores of the ſkin and ſhell ; that ſeeming to be the reaſon, why eggs long kept have uſually within the ſhell a manifeſt, and ſometimes very conſiderable cavity unfilled with either yolk or white ; which cavity ſeems to have been left by the receſs of the ſubtile parts we have been mentioning : ſo that although the frigorifick atoms ſhould by their ingreſs add ſome, not altogether inſenſible, weight to the egg, yet that would not, unleſs perhaps in the very nick of time, when the congelation is firſt actually made, be taken notice of, by reaſon of the greater decrement of weight, that proceeds from the avolation of the more ſubtile parts of the egg it ſelf.

5. AND to ſatisfy ourſelves about this matter, we took four hen eggs, and counterpoiſed them carefully in a good pair of ſcales, which were ſuſpended at a frame, that the balance might be kept unſtirred in a quiet room, wherein we had placed it ; and ſuffering it to continue there for a pretty while, we obſerved, that though it were winter, and though the room, wherein it ſtood, were deſtitute of a chimney, yet that ſcale, wherein the eggs lay, did almoſt grow manifeſtly lighter ; ſo that it was requiſite, from time to time, to take a grain out of the oppoſite ſcale, to reduce the balance to an æquilibrium. And by this means we found the eggs, after ſome time, to have loſt eight grains of their former weight : but how much more they would have loſt, if we had continued the experiment, the need we had of the ſcales kept us from diſcovering.

6. UPON this occaſion I will add, that I uſed ſome endeavours to ſatisfy my ſelf about this inquiry, *viz.* whether eggs being once actually frozen (for thoſe mentioned in the former note, might loſe their weight before they were ſo) and kept in a pair of good ſcales faſtened to a frame in ſome quiet place, well fenced from the ſun, would by the cold of the air, in freezing weather, be kept for any conſiderable time, without a ſenſible diminution of weight : but an unexpected thaw hindered us from ſeeing the ſucceſs of what we deſigned of this nature, both as to eggs, and alſo ſome other bodies : for if the experiment were very carefully tried upon a competent variety of them, it might poſſibly aſſiſt us to gueſs, eſpecially in camphire, and ſome other eaſily exhalable bodies, what intereſt cold may have in ſuppreſſing or diminiſhing the expiration of their effluvia.

7. BUT to return to the weight of bodies frozen and unfrozen, we attempted to diſcover ſomewhat about it by ſeveral ways, according as the differing accommodations, we were furniſhed with, permitted. And of theſe trials I will mention four or five, as well of the leſs, as of the more accurate, as my memory or notes ſupply me with them.

8. ONE of the leſs accurate ways we always imployed to try, whether ice, in which, according to the Atomiſts, great ſtore of theſe corpuſcles muſt be wedged, would not, upon their expulſion or receſs, leave the water lighter than was the ice, was that, which follows ; wherein, to haſten the experiment, we mingled a little ſalt. And though we foreſaw, there would be a difficulty from the adheſion of the vapours of the external air to the outſide of the glaſs we were to employ, we thought that inconvenience might be remedied by well wiping off the froſt, or dew, from the outſide of the glaſs, till it were clean and dry : the event of the trial we find ſuccinctly ſet down among our notes as follows. [A ſingle phial ſealed up with ice and ſalt, being wiped dry, and weighed, was found to weigh four ounces four drachms and a half : when it was quite thawed, it was found to weigh ſomewhat more than a grain leſs than its former counterpoiſe.]

BUT more accurate and ſatisfactory trials about this matter, I find thus ſet down in one of my papers :

9. [WE took a phial more thin than thoſe, that are commonly uſed, that, of the aggregate of that and the liquor, the glaſs might make ſo much the leſſer part. This phial was furniſhed with a ſomewhat long neck, which at the flame of the lamp was drawn by degrees ſlenderer and ſlenderer, that being very narrow at the top, it might the more readily and conveniently be ſealed, notwithſtanding the waters being in it : then we almoſt filled it with that liquor, I ſay almoſt, becauſe a competent ſpace ought to be left unfilled, to allow the water, ſwelled by glaciation, room to expand it ſelf. This phial, with the liquor in it, was placed in a mixture of ſnow and ſalt after our uſual manner ; and when the glaſs appeared almoſt full of ice, it was taken out, and nimbly cloſed with *Hermes*'s ſeal. Preſently after, this was weighed in a pair of very good ſcales, and the phial together with the contained liquor, amounted to ℥v. ʒ8. gr. ß. which yet was not all ice, becauſe theſe things could not be done ſo nimbly, but that ſome of the ice began to thaw, before we were able to diſpatch them quite. The phial thus ſealed being removed, and ſuffered for two or three hours to thaw, when the ice was vaniſhed, we weighed again the ſealed glaſs in the ſame ſcales,

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ſcales, and found, that it weighed, as before; at leaſt, if there were any difference, it ſeemed to weigh a little more.] But this increment, that amounted not quite to $\frac{1}{2}$ a grain, might eaſily be attributed to ſome difference in the weights and grains themſelves, wherein it is not eaſy to find a perfect exactneſs, or to ſome little unheeded moiſture, that might adhere to ſome part of the phial.]

10. AND becauſe it may be wiſhed, that as the experiment ſhews the weight of ice diſſolved into water, to be the ſame with that of the ſolid ice; ſo we had tried, whether the weight of water congealed into ice would be the ſame with that of the former fluid water, we will ſubjoin what immediately follows in the ſame paper, in theſe words.

11. [WE took a ſealed phial, very thin, that it might be lighter, but not ſo large as the other, by about a third, as amounting in the lately mentioned ſcales but to ℥iiij. ʒij. gr. 41. when we had ſealed it up with the water in it. This phial we placed, as we had done the other, in a mixture of ſnow and ſalt, freezing it warily, leſt being ſealed it ſhould break; then we removed it into the ſame ſcales, to try, whether it had got any weight by the ſuppoſed ſubingreſſion of the atoms of cold, which many learned men take to be the efficients of congelation; but it either weighed juſt as before, or if there were any difference, it ſeemed to have loſt $\frac{1}{4}$ of a grain. Being ſuffered to thaw, and put into the ſame ſcales again, it weighed juſt as much as it did when frozen, though the weights were numerically the ſame, and about $\frac{1}{8}$ would ſway the ſcales, or at leaſt be ſenſible upon them. But note, that I was careful this laſt time to wipe the outſide of the glaſs with a linen cloth, becauſe I have obſerved, according to what I elſewhere deliver, that, in caſe ice be any thing haſtily thawed, it may produce a dew on the outſide of the glaſs, as I ſuſpected that even the warm air might in ſome meaſure do in this: and if it had not been for this ſuſpicion, ſome adhering dew, that I was thereby enabled to detect and wipe off, before I took the phial into the ſcales, might eaſily have impoſed upon us.

12. THESE trials I preſume may give ſome ſatisfaction about the enquiry, for the reſolving whereof I thought fit to make them.

13. BUT I was alſo deſirous to ſee, whether any difference, as to weight, would be produced by freezing and thawing (if I may uſe thoſe expreſſions in this caſe) iron, ſtone, wood, or the like ſolid and permanent bodies, which I intended to have exactly weighed before and after their being expoſed to the air, and alſo after the froſt was gone, (and all this againſt counterpoiſes not expoſed to ſo great a cold) would diſcover any ſenſible alteration, as to weight, that might ſafely be aſcribed to the cold. And though avocations, and the negligence of one, that we employed, kept us from bringing the matter to ſuch an iſſue as was deſired, yet the trials ſeemed not altogether irrational, ſince we have formerly made it probable (and have ſince met with freſh inſtances to confirm it) that even ſtones, and metals, may reſent ſome change of texture by the operations of ſome degrees of cold. And indeed induced by ſuch conſiderations of that kind, as ſeemed the leaſt doubtful, I remember I ſometime made ſeveral experiments of the weight of ſome metals, and ſtones, both before and after they had been much expoſed to a more vehement cold, than would have ſufficed to turn water into ice; and alſo after they had been, if I may ſo ſpeak, thawed in a warm air. But the paper, in which we regiſtered the events of theſe trials, having been miſlaid, I dare not charge my memory with the particulars. Only, if I miſtake not, one or two of the ſtones ſeemed to have increaſed in weight, after having been buried in our frigorifick mixture, which I was apt to impute to ſome particles of the ice reſolved into water by the ſalt, that was mingled with it, and (being perhaps made more piercing by the ſaline particles aſſociated with them) imbibed into the pores of the ſtone. For I remember, that having procured an experiment, that I then wanted conveniency to try myſelf, to be made by an ingenious perſon, upon a ſtone hard enough to bear a good poliſh, I was by him informed, that the ſtone, by having been kept a while in water, did, though it were afterwards wiped dry, diſcover a manifeſt increaſe of weight: and in confirmation of my conjecture, I ſhall add, that from a ſort of ſtones, that are of a texture cloſe enough to be uſually poliſhed, I did, as I expected, obtain, by diſtillation, (and that without a naked fire) a conſiderable quantity of an almoſt inſipid liquor, which I ſuſpected to be in good part but water ſoaked into the ſtone, for reaſons, that it is not worth while here to diſcourſe of; the cauſe of my mentioning theſe particulars being, that (I hope) they may make thoſe, that ſhall hereafter try ſuch experiments, cautious how they draw inferences from them, and may invite them to expoſe the bodies, they would make trial of, rather to the cold of the free air in very ſharp weather, (for want of which, we ourſelves could not do what we adviſe) than to artificial glaciations at leaſt, unleſs they be ſo ordered, that nothing that is moiſt come to touch thoſe bodies to be wrought upon.

14. BUT ſuch trials as theſe newly mentioned, and others of the like kind, we muſt leave to be proſecuted by thoſe, that are furniſhed with accurate ſcales, and leiſure; for want of the latter of which, and ſometimes too of the former, we were fain to give over the purſuit of them: which troubled us the leſs, becauſe thoſe made with the ſealed phials were diligently made; and as for divers others, we made them, as we were ſaying, more to be able to gratify others, than to ſatisfy ourſelves; becauſe though in caſe there ſhould unqueſtionably appear ſome ſenſible increaſe or decrement of weight, upon that, which the Atomiſts would call the *acceſſion or expiration* of frigorifick corpuſcles, it would afford a plauſible argument in favour of the Epicurean doctrine, about the generation of ice: yet if no ſuch change of weight ſhould be found upon the freezing or the thawing of the water, or any other body, I doubt whether it may, on the

contrary,

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contrary, be ſafely concluded, that the Atomiſts theory of cold is falſe. For poſſibly they may pretend, that the atoms of cold may not have either gravity or levity, or any more than the ſteams of electrical bodies, or the effluvia of the load-ſtone. Nay, though we ſhould admit the frigorifick corpuſcles not to be altogether devoid of gravity, it may yet be ſaid, that when they invade the body they freeze, they expel thence ſome other pre-exiſtent atoms, that may alſo have ſome little weight; and that the frigorifick corpuſcles, that fly, or are driven away, may be ſucceeded by ſome ſuch, when bodies come to be thawed. But of this no more at preſent.

Appendix to the XXth Title.

THE experiments, we recorded in the foregoing ſection, may perchance in this regard prove more uſeful than I was aware of, that they may keep men from being miſled by the contrary accounts, that I find to have been given of the weight of ice, and water, by no obſcure writers. For, to ſpare one of the famouſeſt of the ancients, *Helmont*, in the treatiſe he calls *Gas Aquæ*, where he gives an account of the congelation of water; which I confeſs to be unintelligible enough to me, and where he is pleaſed to aſcribe to I know not what extenuation of part of the ſulphur he ſuppoſes to be in water, that levity of ice, which the bubbles, it contains, afford us an intelligible and ready account of, delivers very poſitively this experiment. *Imple* (ſays he, *Num.* 35.) *lagenam vitream & magnam fruſtis glaciei, collum verò claudatur ſigillo Hermetis, id eſt, per vitri ibidem liquationem: ponatur hæc tum lagena in bilance, adjecto pondere in oppoſitum, & videbis, quod propemodum octava ſui parte aqua poſt reſolutam glaciem erit ponderoſior ſeipſa glacie. Quod cum milleſies ex eadem aqua fieri poſſit*, &c. Thus far *Helmont*, who in caſe he take *lagena vitrea* in the ordinary acception of the word, would have made us ſome amends for this erroneous account, if he had taught us the way, how he could ſeal ſuch a broad veſſel, as a glaſs flaggon, hermetically. But what has been delivered in the foregoing ſection, will ſufficiently ſhew, what is to be thought of this experiment of *Helmont*. And for further confirmation, we have ſeveral times weighed ice frozen, and reduced to water, without finding any cauſe to doubt, but that *Helmont* was miſtaken. And particularly upon the laſt trial I made of this kind, having filled a wide-mouthed glaſs with ſolid fragments of ice, together with it, amounting to a pound (of which the glaſs alone weighed ſomewhat above five ounces) I whelmed over the mouth of it another flat bottomed glaſs, that if any vapours ſhould aſcend, they might be condenſed into drops, as in the like caſe I had formerly obſerved them to do. And this ice being thawed in a warm room, as no drops were ſeen to ſtick to the inſide of the inverted glaſs, ſo the other glaſs being again put into the ſame ſcales, appeared almoſt exactly of the ſame weight as formerly; whereas the ice alone, that had been diſſolved, amounting to much above eight ounces, according to *Helmont*'s proportion, the weights ſhould have been augmented by a whole ounce at leaſt: and I make little doubt, but that if the experiment had been tried in greater quantities of ice, the event would have been very little, if at all different. But I purpoſely choſe, in the ſtatical experiments about cold, to make my trials in no greater quantities of matter than I have done, becauſe it is very difficult to get ſcales ſtrong enough to weigh, without being injured, much greater weights, and yet be accurate enough to diſcover truly ſuch ſmall differences, as are fit to be taken notice of in ſuch experiments. But to return to *Helmont*; Notwithſtanding all that we have ſaid againſt what he delivers about the weight of ice, yet becauſe I take this inquiſitive chymiſt to have been, in ſpite of all his extravagancies, a benefactor to experimental learning, I am willing to ſuggeſt on his behalf, that poſſibly much of the additional weight he aſcribes to the reſolved ice, may have proceeded from that which would not have been taken notice of by an ordinary experimenter. For (as I not long ſince intimated) I have (ſometimes purpoſely, and ſometimes by chance) by thawing ice in cloſed veſſels ſomewhat haſtily, produced a copious dew on the outſide of the veſſels; which dew, as being made by the condenſed vapours of the ambient air, ought to be wiped off, before the veſſel be put into the ſcales to weigh the melted ice: and it is poſſible alſo, that *Helmont* may have erred in the manner of weighing his *Lagena*, whatever he mean by it; it being uſual even for learned men, that are not verſed in ſtaticks, to miſtake in experiments, which require, that things be ſkilfully and nicely weighed. How far this excuſe may be applied to a late * commentator upon *Ariſtotle*'s meteors, who ſays, he tried, that water frozen is heavier than unfrozen; being a ſtranger to that author's writings, I ſhall not conſider: only whereas *Helmont* and he ſeem to agree very little in their affirmations, it will be perhaps more difficult to accord them, than to determine, by the help of our formerly regiſtered experiments, what may be thought of both their relations.

YET I ſhall add on this occaſion, that if I had not deviſed the abovementioned way of freezing water by art in hermetically ſcaled glaſſes, I ſhould have found it difficult to reduce, what is affirmed by *Manelphus*, which I then dreamt not of, to an accurate experiment: for though I had imployed a ſealed glaſs, (which I have not heard, that he or any other has yet made uſe of to that purpoſe) yet if I had in that veſſel expoſed the water to be frozen the common way, it is odds (though it be not abſolutely certain) that the water beginning, as it is wont, to congeal at the top, the expanſion of the ſubſequently freezing water would break the glaſs, and ſo ſpoil the experiment. And for the ſame reaſon I have ſometimes in vain attempted to examine the weight of water frozen,

* — *Hinc gelidam congelatamque aquam graviorem eſſe non congelata expertus eſt Jo. Manelphus.* Com. in 4. Meteor. Ariſtot. inquit Tho. Bartholinus de Nivis uſu, cap. 12.

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frozen by nature, according to her wonted method in open phials. And if, inſtead of glaſſes, you make uſe of ſtrong earthen veſſels, there is danger, that ſomething may be imbibed, or adhere to the porous veſſel, and increaſe the weight; and by ſome ſuch way, or by ſome miſtake in weighing, it is very probable *Manelphus* may have been deceived: which I am the more inclined to think, if we ſuppoſe him a ſincere writer, not only becauſe of ſome things I have taken notice of, about congelations made in earthen veſſels, but becauſe, when I have, inſtead of an earthen, made uſe of a metalline pottinger, (both which ſorts of veſſels have in common this convenience, that their ponderouſneſs makes them leſs fit for accurate ſcales) there appeared cauſe to ſuſpect, either that our author did not uſe metalline veſſels, or, which I rather ſuſpect, that he wanted ſkill or diligence in weighing. For as I find no intimation of his having employed any peculiar or artificial ſort of veſſels, ſo, if he uſed ſuch as we have newly been ſpeaking of, and had weighed them carefully, I cannot but think, that inſtead of finding the ice heavier than the water it was made of, he would have rather found it lighter. For I remember, that having once expoſed all night a pottinger, almoſt full of common water, to an exceeding ſharp air, and having cauſed it the next morning to be brought me, when the liquor was throughly frozen, I found it to have loſt about 50 grains (if I miſremember not) of its former weight. And though this event were conſonant enough to my conjectures, yet for greater certainty I repeated the experiments another froſty night with this new caution; that the pottinger and water, together with the counterpoiſe, were kept ſuſpended in the ſcales, to be ſure, that no effuſion of any part of the water in carrying it abroad to the open air ſhould be made without being taken notice of: but the next morning (ſomewhat late) the veſſel, with the contained water now congealed, appeared to have loſt about 60 grains; and with the like ſucceſs the trial was reiterated once more, and that in weather ſo ſharp, that I am not apt to think, the water expoſed by *Manelphus* began to freeze ſooner than ours. But the event was not unexpected; for beſides that I conſidered, that in theſe kind of experiments, part of the water, notwithſtanding the exceeding coldneſs of the air, muſt in all likelihood fly away before the ſurface of it began to be congealed, I judge it not improbable, that not only the fluid part, but even that, which was already congealed, might continually loſe ſome of its corpuſcles, and by their receſs loſe alſo ſomwehat of its weight. And leſt theſe conjectures ſhould ſeem too unlikely, it will not be amiſs to add in favour of the firſt of them, that having purpoſely provided a large pewter box, with a cover to ſcrew on it, and having fill'd it almoſt full of water, (I ſay almoſt, becauſe if the veſſel had been quite full, the congealing cold might have burſt it) and carefully weighed the aggregate of both (which amounted to ℥v. ʒii. gr. 11. whereof the veſſel weighed ʒii. ʒvß, and gr. 8.) we expoſed the water after the top of the pot was ſcrewed on, to hinder the avolation of it, to the freezing air all night, and the next morning found it frozen from the top to the bottom, though not uniformly and perfectly, but found not one grain difference betwixt its preſent and its former weight. And as for the ſecond conjecture newly propoſed, though it may ſeem ſomewhat ſtrange, yet it is confirmable by this experiment, that having placed divers lumps of ſolid ice in a pottinger, which together with them weigh'd a pound, conſiſting of 16ʒ. and having expoſed theſe things in the ſame ſcales, wherein they were weighed, to the free air, on a very froſty night, we found the ice to have loſt the next morning 24 grains of its weight; and the weather continuing ſo cold, that it froze hard all day long in the ſhade, I gave order to have it kept out of the ſun in the ſame ſcales, during all that time, and a good part of the following night, and then weighing it the ſecond time, found, that the whole decrement of weight did now amount to five grains above two drachms, though the weight of the ice, without the pottinger were but about ſeven ounces: and when we had kept about 13 ounces of ice, in a very froſty night, expoſed to the cold air, it had loſt, as early as the next morning, a good deal above two drachms of its former weight. But theſe ſtatical obſervations have perhaps already but too much ſwelled this Appendix.

TITLE XXI.

Promiſcuous experiments and obſervations concerning cold.

1. I Hope it will not be imagined, that I have ſuch narrow thoughts of the ſubject I treat of, Cold, as to believe, that I have comprized under thoſe few titles, prefixed to the Sections of this hiſtorical treatiſe, all the particulars, that I knew to belong to ſo comprehenſive a theme; as would readily appear, if I thought it convenient to inſert here the ſcheme of articles of inquiry, that I drew up to direct my ſelf, what inquiries and experiments to make. But though there were divers of thoſe heads, to which I could ſay ſo little, that I judged it improper to aſſign them diſtinct titles, becauſe, as to ſome of them, I had not time and opportunity to make thoſe trials, which, if I had not wanted thoſe requiſites, might have been made, even here in *England*; and becauſe alſo, as to more of them, I conceived my ſelf unable to produce, in this temperate climate, ſo ſtrong and durable a cold, as ſeem'd neceſſary to make the trials, that might be referred to them, ſucceed ſo far, as to ſatisfy my doubts, either affirmatively, or negatively: Though I ſay, theſe and ſome other conſiderations kept me from increaſing the number of the titles, among which I have diſtributed the experiments and obſervations, that make up the foregoing part of this treatiſe, yet ſince divers particulars have occurred to me, which though they ſeem not properly reducible to the foregoing titles, do yet belong to the ſubject and deſign of this treatiſe, I think

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think it fit to annex them in this place, and without any other order than that, wherein they ſhall happen to occur to me, throw them into this one ſection; together with ſome looſe experiments, and divers relations, that I have met with among navigators and authors, that have travelled into the northern climates, touching cold, not forbearing to inſert promiſcuouſly among them ſome few *paralipomena*, which, if they had ſeaſonably come to my hands, or into my mind, might have had a more proper place among the foregoing ſections, or have compoſed a title by themſelves. Wherefore though the obſervations will not be altogether unaccompanied with experiments, yet for the reaſons above intimated, much the greater part of what is to be delivered under this title, will conſiſt of collections out of voyages, in which the ſtrange things mentioned being ſuch, as we cannot examine by our own trials, I can equitably be thought anſwerable for the truth of nothing but the citations.

2. I REMEMBER I tried, at ſeveral times, divers experiments, to diſcover, whether or no congelation would by conſtriction of the pores of bodies, or vitiating their texture, or arreſting the motion of their parts, hinder them from emitting thoſe effluvia, that we call odours; but the regiſter of theſe obſervations, being unhappily loſt in one of my late removes, I dare add but theſe few, wherein I have no cauſe to diſtruſt my memory.

3. I DID, in the months of *December* and *January*, at ſeveral times gather differing ſorts of flowers in froſty weather; but in moſt, when they were freſhly gathered, and haſtily ſmelt to, I could ſcarce perceive any ſenſible ſmell; whether it were, that the cauſes above hinted hindered the expiration of the odoriferous ſteams, or that the cold had ſome undiſcerned influence upon the organ of ſmelling, which made the ſenſe more dull, or that the ſame cold kept the alimental juice of the flowers from riſing in ſuch plenty, and abounding ſo much with ſpirituous parts, as was uſual at the more friendly ſeaſon of the year: and this ſeem'd the more likely to be one reaſon of the phænomenon, becauſe moſt of the flowers were flaggy, and as it were, ready to wither; and becauſe alſo a primroſe, that was vigorous and freſh in its kind, had an odour, that was manifeſtly (and it will eaſily be believed, that it was not ſtrongly) ſweet, and genuine.

4. I TOOK alſo, about an ounce, by gueſs, of roſe-water, and putting it into a ſmall phial, after I had ſmelt to it, it was expoſed to freeze in the open air; and when it began to have ice in it, I then ſmelt to it again, but found not the perfume conſiderably, if ſo much as manifeſtly abated: and laſtly, having ſuffered it to continue in the air, that was then very ſharp, 'till it was quite frozen, and diſcovered no liquor, when the phial was turned upſide down, the ice notwithſtanding was not deſtitute of a graceful and genuine ſcent, though it ſeemed ſomewhat faint; but after the ice was reduced to water again, the fragrancy appeared conſiderable. But on this occaſion it will not be improper to ſubjoin this caution, that care muſt be had, in trials of this nature, to make one's eſtimate betimes; for if a man ſhould ſtay too long about it, there is danger, that the warmth of ones breath and face may relax the pores, or thaw the ſurface of the ice, that is held near his noſe, and both free and excite the corpuſcles of ſmell, that are impriſoned there, that ſo inſtead of ice, he may ſmell a liquor. The reaſonableneſs of which advertiſement may be juſtified by an experiment, that I am about to annex. For being pretty well confirmed by the caſual and unwilling obſervations of one of my friends, curious in making ſweet water, that even liquors more eaſy to be ſpoilt than roſe-water would not have their fragrancy deſtroyed, though perhaps impaired, nor ſo much as their odours for the time quite impriſoned and ſuppreſſed by congelation; and this appearing congruous to what I formerly noted of the effluviums, that may, by the decrement of weight, be gathered to iſſue from ice itſelf, I thought it worth while to try, whether ſtinking liquors would not be more altered by congelation, than odoriferous ones. And accordingly having procured ſome rain-water, that had been kept in a tub, 'till it ſtunk ſo ſtrongly, that I could hardly endure it near my noſe, I cauſed a pottinger full of it to be expoſed all night to a very ſharp air; and examining it the next morning, when it was all turned into ice, neither I, nor ſome others, to whom it was offered, could perceive any ſtink at all in it. And having in another place, but with as ſtinking water, repeated the experiment, when the pottinger was the next morning brought to my bed's ſide, I found it to ſmell abominably; whereupon gueſſing, that this difference proceeded from ſome thaw made by the warmth of the room in the ſuperficial parts of the ice, I found it to be ſo indeed, partly by the help of the light, which diſcovered a little liquor upon the ice, and partly by expoſing the veſſel with that liquor in it to the cold air again, by whoſe operations an ice was produced, that was perfectly inodorous: and I remember, that one of theſe parcels of ice being thawed, ſeemed to be leſs ſtinking than before * it had been frozen; and if I had not been diverted, I ſhould have tried, whether this ice, that did not omit odours, would emit, like other ice, effluvia, diſcoverable by the ſcales: for whether the ice would loſe of its weight, which ſeemed the more probable, or would not, the event may afford a not inconſiderable hint.

5. IT is a thing not only remarkable, but ſcarce credible, that though the cold has ſuch ſtrange and tragical effects at *Moſcow*, and elſewhere in cold countries, as we have formerly mentioned, eſpecially a little after the beginning of the 18th and ſomewhere in the 19th ſection; yet this happens to the Ruſſians and Livonians

* If it had not been for the negligence or miſtake of one, that I ordered in my abſence, to freeze and thaw the ſame water, divers times one after another, I might have added the ſucceſs of that experiment, which I was ſorry to miſs of, becauſe it might poſſibly have afforded an uſeful hint about a way to correct ſtinking waters, in ſome climates or ſeaſon.

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Livonians themſelves, who, not only by living in ſuch a country, muſt be accuſtomed to bitter colds, but who, to harden themſelves to the cold, have uſed themſelves, and thereby brought themſelves to be able to paſs to a great degree of cold, from no leſs a degree of heat, without any viſible prejudice to their healths. For I remember, that having inquired of a virtuoſo of unqueſtionable credit, whether the report of our merchants, concerning this ſtrange cuſtom of the Muſcovites and Livonians, were certainly true, he aſſured me, that it was ſo, at leaſt as to the Livonians, among whom, being in their country, he had known it practiſed. And the ſame was affirmed to me by an ingenious perſon, a doctor of divinity, that had occaſion ſome years ſince to make a journey to *Moſcow*. And the tradition is abundantly confirmed by *Olearius*, whoſe teſtimony we ſhall ſubjoin, becauſe this ſeems one of the eminenteſt, and leaſt credible inſtances, that we have yet met with of the ſtrange power, that cuſtom may have, even upon the bodies of men. 'It is a wonderful thing ſays he, to 'ſee how far thoſe bodies (ſpeaking of the Ruſſians, that are accuſtomed and hardened to 'the cold) can endure heat, and how when 'it makes them ready to faint, they go out 'of their ſtoves ſtark naked, both men and 'women, and caſt themſelves into cold wa-'ter, or cauſe it to be poured upon their 'bodies, and even in winter wallow in the 'ſnow.' To which paſſage our author adds, from his own obſervation, particular examples of the truth of what he delivers.

Olearius, livre 3. pag. 168.

6. I HAD ſeveral years ſince, the curioſity to try, whether there were any truth in that tradition, which is confidently affirmed, (and experience by ſome is pretended for it) that the beams of the moon are cold; but though I were not able to find any ſuch matter, either by the united beams of the moon, or by the ſame beams concentred by ſuch burning-glaſſes as I then had; yet having ſome years after furniſhed my ſelf with a large and extraordinary good metalline concave, I reſolved to try, whether thoſe beams were not only devoid of cold, but alſo ſomewhat warmiſh, ſince they are the ſun-beams, though reflected from the moon. And we ſee, that his beams, though reflected from glaſſes not ſhaped for burning, may yet produce ſome not inſenſible degree of warmth. But notwithſtanding my care to make my trials in clear weather, when the moon was about the full, and, if I miſremember not, with a weather-glaſs, I could not perceive by any concentration of the lunar beams, no not upon a black object, that her light did produce any ſenſible degree, either of cold or heat; but perhaps others, with very large glaſſes, may be more ſucceſsful in their trials.

7. ON this occaſion I ſhall add, that meeting the other day in a bookſeller's ſhop with the works of the learned phyſician *Sanctorius* (whom I look upon as an inquiſitive man, conſidering when and where he lived) a picture drew my eyes to take off an experiment, whereby he thinks to evince the light of the moon to be conſiderably hot; which he ſays, he tried by a burning-glaſs, through which the moon's light being caſt upon the ball of a common weather-glaſs, the water was thereby depreſſed a good way, as appeared to many of his diſciples, amidſt whom the obſervation was made. But though this may invite me, when opportunity ſhall ſerve, to repeat my trials, yet I muſt till then ſuſpend my aſſent to his concluſion. For my burning-glaſs was much better, than by the narrative his ſeems to have been; and my trials were perhaps at leaſt as carefully and impartially made, as his experiment, in which this may probably have impoſed upon him; that performing the experiment, a company of his ſcholars, whilſt they ſtood round about his thermoſcope, and ſtooped (as in likelihood their curioſity made them to do) to ſee by ſo dim a light the event of the experiment, the unheeded warmth of their breath and bodies might, unawares to *Sanctorius*, ſomewhat affect the air included in the weather-glaſs, and by rarifying it, cauſe that depreſſion of the water, which he aſcribed to the moon-beams. But becauſe this is a conjecture, I intend, if God permit, to repeat the experiment, when I ſhall have opportunity to do it with a more tender weather-glaſs, than I had by me, when I made my former obſervations.

To the XIth TITLE.

BY the unſucceſsfulneſs of the former attempts made with an iron inſtrument, I was invited, eſpecially being at another place, where I was unfurniſhed with ſuch hollow iron balls, as are mentioned *numb.* 10. to ſubſtitute the following experiment. I cauſed a ſkilful ſmith to take a piſtol-barrel, gueſſed to be of about two foot in length, and of a proportionable bore; and when he had, by riveting in a piece of iron, exactly ſtopped the touch-hole, I cauſed him to fit to the noſe of the barrel a ſcrew, to go as cloſe as well he could make it: and then having filled it to the very top with water, I cauſed the ſcrew to be thruſt in (which could not be done without the effuſion of ſome of the water) as forcibly as the party I imployed was able to do it, that the water, dilated by congelation, might not either drive out the ſcrew, or get between it and the top of the barrel. And having then ſuſpended this barrel in a perpendicular poſture in the free air, in a very cold night, which then unexpectedly happened, and gave me the opportunity of making the trial, I found the next morning, that the intumeſcent water had thruſt out a great part of the ſcrew, notwithſtanding, that, to fill up intervals, I had oiled it before; and was got out betwixt the remaining part of it, and the barrel, as appeared by ſome ice, that was got out, and ſtuck round about the ſcrew. Wherefore, the bitter cold continuing one day longer, I did the next night cauſe the intervals, that might be left betwixt the male and female ſcrews, to be filled up with melted bees wax, which I preſumed would keep the ſcrew from being turned by the water: and having in other points proceeded as formerly, I found the next morning that

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that the ſcrew held, as I deſired, and the preceding night having been exceeding bitter, the cold had ſo forcibly congealed, and expanded the water, that it burſt the iron barrel ſomewhat near the top, and made a conſiderable and oblique crack in it, about which a pretty quantity of ice appeared to ſtick; beſides that, there were three or four other flaws, at ſome of which ſmaller quantities of water appeared to have got out. At the ſame time, that I beſpoke this iron barrel of the ſmith, I ordered him to get me a braſs one filled up after the ſame manner, to make the experiment the more ſatisfactory. But though he could not procure it, yet the ſucceſs was not unwelcome, becauſe it was manifeſt, that there were cracks in the iron in one place conſpicuous, and in others eaſily diſcoverable, by blowing into the barrel, and putting on the outſide of the ſuſpected parts, either ſpittle or ſome fit liquor, whoſe agitation plainly diſcloſed the egreſs of the wind; and there appeared ſmall cauſe to doubt, but that theſe cracks were produced by the operation of the cold; ſince not only the ſmith was a ſkilful man in his trade, and one, that I uſed to imploy about inſtruments, and alſo the barrel had been ſometimes kept many hours filled with water, without appearing other than very ſtanch: but, which is the conſiderableſt circumſtance the night before, the froſt, as I lately noted, was not able to make the water break out at any of theſe clefts, though it were able to force it ſelf a way out at the ſcrew, in ſpight of all the care we had taken to make it go cloſe. I have only this circumſtance to add about this matter, that when by thawing one part of the ice, ſome pieces of the reſt were got out of the barrel, all I took notice of appeared to be full enough of bubbles, but yet ſuch as ſeemed leſſer than ordinary, whether they were ſo by chance, or were determined to be ſo, by the reſiſtance or compreſſion, which the freezing water found upon its endeavouring to expand its ſelf in the barrel.

Appendix to the XVIIth *Title.*

LONG ſince the writing of the foregoing ſection, meeting with a paſſage in *Bartholinus*, where he vouches *Cabæus* for the experiment of congealing water (without limiting it to any ſeaſon of the year) by putting ſalt-petre into it, and ſhaking it ſtrongly, I was thereby confirmed, that I was not miſtaken, in ſuppoſing, that *Gaſſendus* (mentioned in the former ſection) did not exclude that corporal and viſible nitre out of the number of the grand efficients of congelation. For *Cabæus* having publiſhed his comment upon *Ariſtotle*'s meteors (whence this experiment is taken by *Bartholinus*) before *Gaſſendus* publiſhed this book, it is probable, that he as well as others borrowed the experiment from him; and *Cabæus*, as *Bartholinus* quotes him, preſcribes the putting the ſalt-petre itſelf into water, which being a while put into a briſk motion, will, after ſome agitation, not only refrigerate that water, but bring it to a true and proper congelation.

WHEREFORE ſuſpecting, that this relation, wherein *Bartholinus* ſays, he will believe him without an oath, may have given riſe to the opinions and affirmations of thoſe ingenious writers, that have ſince aſcribed ſuch wonderful coldneſs to nitre, and finding in *Bartholinus*, that *Cabæus*'s proportion betwixt the nitre and the water, was that of 35 to 100, that is, almoſt as one to three, I thought it very well worth while to make trial of an experiment, which ſeemed to me little leſs unlikely than conſiderable.

I TOOK then a pound of good ſalt-petre, and near three pound of common water (to obſerve the more narrowly *Cabæus*'s proportion) theſe being put into a large new pipkin, were kept conſtantly and nimbly ſtirred about, ſometimes by me, ſometimes by one or other of the domeſticks relieving one another, when they were weary; but though the mixture was with a kind of broad glaſs ſpattle kept in a briſk motion, that for the moſt part was after the manner of a whirl-pool, and ſometimes a more confuſed agitation, and though we kept it thus ſtirring for almoſt an hour and a half, till we ſaw no likelihood of effecting any thing by trying our ſelves any further, yet not only we could not perceive that any atom of true ice was produced; whereas, according to our authors, we might have expected a true and perfect congelation of all, or the greateſt part of the water, but we did not find, that there was ſo much as any freezing of the vapours on the outſide of the veſſel; and for this reaſon we thought fit about the ſame time, to try the experiments by another kind of agitation, and mixing two ounces of ſalt-petre with about ſix of water, in a conveniently ſized phial, we did ſeveral of us ſucceſſively vehemently ſhake the phial to and fro, till we were almoſt tired; but neither this way was there produced the leaſt ice within the glaſs, or the leaſt congelation of the vapours of the air on the outſide of it. It is true, that when ſo great a proportion of ſalt-petre began to be diſſolved in the pipkin, the water had a ſenſible increaſe of coldneſs, which afterwards ſeemed to diminiſh, when once the nitre was diſſolved; but not to mention, that (if I much miſtake not) we have obſerved the water to be refrigerated, when, upon the diſſolution of common ſalt, multitudes of actually cold and ſolid corpuſcles came to be every way diſperſed through it; this coldneſs produced by the nitre was very far ſhort of the degree requiſite to congelation: for to ſatisfy myſelf, that my ſenſe did not miſ-inform me, I took a good ſealed weather-glaſs of about ten or twelve inches long, and immerſing it into the cold mixture of nitre and water, I obſerved the tinged ſpirit of wine in the ſtem to deſcend not inconſiderably; and when I perceived that degree of cold to have wrought its effect, I removed the thermoſcope into a phial filled with common water, about which I had cauſed to be placed a mixture of beaten ice and ſalt, to refrigerate the contained water, in which the ball of the inſtrument being placed, the ſpirit of wine haſtily deſcended two or three inches

below that place, at which it ſtood, when it was removed out of the nitrous ſolution: and, for further ſatisfaction, removing the thermoſcope once again into that ſolution, the ſpirit of wine in the ſtem was haſtily impelled up, as if the bubble had been put into warm water. And, once more, the weather-glaſs being removed into the formerly mentioned refrigerated water, the tinged liquor began to fall down haſtily again, and, within a while, ſubſided almoſt into the bubble; whereupon, to avoid injuring the inſtrument, we thought fit to take it out. So that, upon the whole matter, if the learned *Cabæus* were not deluded by miſtaking ſome cryſtals of nitre (which I have obſerved eaſily to ſhoot again in water, that has been glutted with it) for true and proper ice, I cannot but wonder at his aſſertion, and muſt take the liberty to think my ſelf warranted, by ſo many harmonious trials, as I have found unfavourable to the ſuppoſed ſupremeneſs of cold in ſalt-petre, to retain my former opinion about it, till more ſucceſsful experiments withdraw me from it.

IT is a received tradition, among the watermen and many others, that the rivers, if not ponds alſo, are frozen firſt at the bottom, and begin to thaw there. But though I find this opinion to be in requeſt, not only among Engliſh watermen, but among the French too, yet I think it may be very warrantably queſtioned: for it is evident, in waters we expoſe to freeze in large veſſels, that the congelations begin at the ſurface, where the liquor is contiguous to the air; and thence, as the cold continues to prevail, the ice increaſes, and thickens downwards: and therefore we ſee, that frogs retire themſelves, in froſty weather, to the bottom of ditches, whence I have had many of them taken out, very briſk and vigorous, from under the thick ice that covered the water. And I have been informed by an obſerving perſon, that, at leaſt in ſome places, it is uſual, in winter, for ſhoals of fiſhes to retire to thoſe depths of the ſea, if not of rivers alſo, where they are not to be found in ſummer. Beſides, if rivers were frozen at the bottom, we muſt very frequently meet, in the emergent pieces of ice, the ſhapes of thoſe irregular cavities and protuberances, that are often to be found in the uneven ſoils, over which rivers take their courſe; whereas, generally, thoſe emergent pieces of ice are flat, as thoſe flakes, that are generated on the ſurface of the water. Moreover, if even deep rivers freeze firſt at the bottom, why ſhould not very many ſprings and wells freeze firſt at the bottom too? the contrary of which nevertheleſs is obvious to be obſerved. In confirmation of all which, we may make uſe of what we formerly noted, (in the ſection of the *Primum Frigidum*) about the practice of the maſters of the French ſalt-works, who, by overflowing the banks and cauſways all the winter, keep them from being ſpoiled by the froſt; which could not be done, if the waters, they ſtand under, froze as well at the bottom, as at the top.

BUT, I find, that that, which deceives our watermen, is, that they often obſerve flakes of ice to aſcend from the bottom of rivers, to the top; and indeed it often happens, that, after the hard froſt has continued a while, theſe emergent pieces of ice do very much contribute to the freezing over of rivers. For, coming, in ſome of the narrower parts of them, to be ſtopped by the ſuperficial ice, that reaches on each ſide of the river, a good way from the banks towards the middle, thoſe flat icy bodies are eaſily cemented by the violence of the cold, and, by the help of the contiguous water, to one another, and by degrees ſtreightning, and at length choaking up the paſſage, they give a ſtop to the other flakes of ice, that either emerging from the bottom, or looſened from the banks of the river, or carried down the ſtream towards them; and theſe being alſo, by the ſame cold, cemented to the reſt, the river is at length quite frozen over. And the reaſon, why ſo many flakes of ice come from the bottom of the river, ſeems to be, that, after the water has been frozen all along near the banks, either the warmth of the ſun by day, or ſome of thoſe many caſualties, that may perform ſuch a thing, does by thawing the ground, or otherwiſe, looſen many pieces of that ice together with the earth, ſtones, *&c.* that they adhered to, from the more ſtable parts of the banks; and theſe heavy bodies do, by their weight, carry down with them the ice they are faſtened to; but then the water at the bottom of the river being warm, in compariſon of the air, in froſty weather, (ſince that even common water is ſo, we have manifeſted by experience, where we ſhew how much ſooner ice will be diſſolved in water, than thawed in air) the diſperſed ice is by degrees ſo wrought upon, that thoſe parts, by which it held to the ſtones, earth, or other heavy bodies, being reſolved, the remaining ice being much lighter, bulk for bulk, than water, gets looſe, and ſtraightway emerges, and may perhaps carry up with it divers ſtones and clods of earth, that may yet happen to ſtick to it, or be incloſed in it, the ſight of which perſuades the waterman, that the flakes of ice were generated at the bottom of the river; whereas a large piece of ice may carry up, and ſupport bodies of that kind, of a great bigneſs, in caſe the ice it ſelf be proportionably great, ſo that the aggregate of the ice, and heavy bodies, exceed not the weight of an equal bulk of water. On which occaſion I remember, that Captain *James Hall*, in a voyage extant in *Purchas*, relates, that, upon a large piece of ice in the ſea, they found a great ſtone, which they judged to be three hundred pound weight. But, of the tradition of the watermen we ſhall ſay no more, than that this hath been diſcourſed, but upon no great information, though the beſt we could procure; ſo that, for further ſatisfaction, it were to be deſired, that, either by ſending down a diver, or by letting down ſome inſtrument fit to feel (if I may ſo ſpeak) the bottom of rivers with, and to try, whether ice, if it met with any, be looſe from, or uniformly coherent to the ground, and alſo bring up parcels of whatever ſtuff it meets with there, the matter were, by competent experiments, put out of doubt.

In the Section touching the duration of ice.

WE took a ſealed weather-glaſs, furniſhed with

with ſpirit of wine, and though not above ten inches long in all, yet ſenſible enough; and, having cauſed a hole to be made in the cover of a box, juſt wide enough for the ſmall end of the glaſs to be thruſt in at, we inverted the thermometer, ſo that the ball of it reſted upon the cover of a box, and the pipe pointed directly downwards. Then we placed about the ball a little beaten ice and ſalt, and obſerved, whether, according to our expectation, the tincted ſpirit, that reached to the middle of the pipe, or thereabouts, would be retracted upon the refrigeration of the liquor in the ball; and accordingly the ſpirit did in a very few minutes aſcend in that ſhort pipe above an inch higher than a mark, whereby we took notice of its former ſtation, and would perhaps have aſcended much more, if the application of the frigorifick mixture had been continued; by which, and another ſucceeding experiment to the ſame purpoſe, it ſeems that the condenſation of liquors by cold, is not always affected by their proper gravity only, which ordinarily may be ſufficient to make the parts fall cloſer together: but whether in our caſe, the contraction be aſſiſted by ſome little tenacity in the liquor, or by the ſpring of ſome little aerial, or other ſpirituous and elaſtick particles, from which the inſtrument was not perfectly freed, when it was ſealed up, or which happened to be generated within it afterwards, will be, among other things, more properly inquired into in another place, where we may have occaſion to make uſe of this experiment.

THERE is a famous tradition, that in *Muſcovy*, and ſome other cold countries, it is uſual out of ponds and rivers to take up good numbers of ſwallows incloſed in pieces of ice; and that the benumbed birds upon the thawingof the ice in a warm room, will come to themſelves again, and fly about amazedly for a while, but not long ſurvive ſo great and ſudden a change. I have in another treatiſe already ſaid ſomewhat about this tradition, and therefore ſhall now ſay no more of it, than theſe two things: firſt, that I ſince was aſſured by a perſon of honour, that is very curious, and was commanded by a (many ways) great prince to enquire out the truth of it, when he was in ſome of thoſe countries, where the thing is ſaid to be familiar enough, and that the eminenteſt and ſobereſt perſons he could aſk affirmed the thing to be true: but, (ſecondly) having lately enquired about this matter of a knowing perſon of quality, that was born and bred in *Poland*, he anſwered me, that in the parts, where he lived, it was a very general and unqueſtionable opinion, that ſwallows often hid themſelves all the winter under water in ponds and lakes, and ſedgy places, and that the fiſhermen, when having broken the ice, they caſt their nets for fiſh, to draw them up benumbed, but not dead, ſo that they quickly in ſtoves recover their wings, but ſeldom after that prolong their lives. But as for their being taken up in ice, he told me, he had not heard of it; though I ſee not, why in caſe they commit themſelves to ſhallow waters, as thoſe of ponds and ſedgy places often are, a ſharp laſting froſt may not ſometimes reach them. And therefore that, which left me the greateſt ſcruple about this tradition, is, that this gentleman, notwithſtanding his curioſity, could not affirm, that ever he himſelf had ſeen any example of the thing he related.

BUT I will take this occaſion to add, that having a mind in froſty weather to try ſome anatomical experiments about frogs; one, that I imployed breaking in a ditch ſome ice, that was very thick, and of which he was to bring me a quantity, found in the water, that was under the ice, good ſtore of frogs (beſides ſome toads) which I found to be very lively, and divers of which I kept for certain uſes a good while after.

To confirm, and to add ſome paralipomena unto what I have delivered in the ſecond, and in the twentieth titles, about the froſt's getting into hard and ſolid bodies, I ſhall here ſubjoin ſome particulars there omitted, which I have learned partly from experiments, and partly from perſons worthy of credit, whom I purpoſely conſulted about this matter.

AND firſt, as to the freezing of wood, we have ſometimes tried it by purpoſely expoſing partly other wood, and partly branches cut off from growing trees, to an intenſe degree of cold, by which the wood ſeemed in one night to be for ſome little depth manifeſtly enough invaded by the froſt. But a domeſtick of mine having a little while ſince had occaſion to fell an old apple-tree, on a day, that had been preceded by a fortnight's bitter froſt, came and informed me, that he found, that the froſt had evidently pierced into the very middle of it, though it were about a foot in diameter. And an experienced artificer, whoſe head and hand were much imployed about the building of great men's houſes, told me, that he had often ſeen here in *England* pieces of timber itſelf manifeſtly frozen, and rendered exceeding difficult to be ſawed, the froſt alſo appearing by evident ſigns to continue in the ſaw-duſt. And therefore it will be the leſs ſtrange, if in *Poland* the effects of cold upon wood be more conſpicuous. For a learned native aſſured me, that in his country it was uſual to have wood frozen ſo hard, that the hatchets would not cut it, but rebound from it; and that it was very uſual to hear in the night a great many loud cracks, almoſt like the reports of piſtols of the ſhingles or wooden tiles, wherewith in many places they cover their houſes inſtead of ſlate; and this, (as I purpoſely aſked) when the weather was dry, and exceſſively cold. When I likewiſe enquired about the thawing of wood, he told me, he had ſeveral times ſeen pieces of timber, which having been thoroughly frozen in the air, did, when brought into rooms, made warm by ſtoves, become covered with a kind of hoar froſt, and made them look white, and that though his bow (which he ſhewed me) were very ſtrong and tough, as being made not of wood, but horn, and other cloſe materials, it would be ſo changed by the froſt, that unleſs ſpecial care were had in the thawing of it, it would break

THAT

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THAT marl and chalk, and other leſs ſolid terreſtrial concretions, will be ſhattered by ſtrong and durable froſts, is obſerved by huſbandmen, who thereby find it the better fitted to manure their land; the texture of thoſe bodies, during whoſe intireneſs the parts moſt proper to feed graſs and corn, are more locked up, being by congelation in great part diſſolved; but that true and ſolid ſtones, wont to be imployed in noble and durable buildings, ſhould be ſpoiled by the froſt, will perhaps to moſt readers ſeem very improbable. And therefore I ſhall here add what I have learned by inquiry of the ingeniouſeſt and moſt experienced maſon I have met with, becauſe it may not only ſurprize moſt readers, but prove an uſeful obſervation to him. Having then enquired of this tradeſman, whether he did not find, that ſome free ſtone, a name vulgarly known, would not be ſpoiled by the froſt, he told me, that he had often obſerved both free ſtone and harder ſtones than that, to be exceedingly ſpoiled by the froſt, and reduced to crack or ſcale off, to the blemiſhing and prejudice of the houſes, that are built of them. But becauſe it may be objected againſt this, that experience ſhews us, that divers of the ſtatelieſt fabricks in *England* have theſe ſtones for their chief materials, and it endure very well the inclemencies of the air; the reply may be, that the difference may not conſiſt in the peculiar natures of the ſtones imployed, but in the ſeveral ſeaſons in which the ſame kind of ſtones are digged out of the quarry. For if they be digged up, when the cold weather is already come in, and imployed in building the ſame winter, they will, upon very hard froſts, be apt to be ſhattered or ſcale; but if they be digged early in the ſummer, ſuffered to lie expoſed to the ſun and air, during all the heat of the ſummer, theſe ſeaſoned ſtones, if I may ſo call them, may out-laſt many ſharp winters unimpaired. It ſeems to me worth trying, whether during their inſolation, if that term may be allowed me, there do not, by the operation of the heat and air upon them, exhale a certain unripe mineral, ſap or moiſture (whoſe receſs may perhaps be diſcovered by weight) which, if it remain in the ſtone, may, by very piercing froſts, be congealed almoſt like the ſap in timber-trees, and ſhatter the texture of the ſtone, which agrees well with what was told me by an underſtanding perſon, that is maſter of a great glaſs-houſe, of whom having purpoſely inquired, whether he did not find, that his great earthen pots, which is made up with as little water as is poſſible, and are deſervedly famous for their durable texture, had not that texture altered and impaired by very piercing froſts; he aſſured me, that if he did not take care to keep the froſt (as they ſpeak) from getting into them, thoſe great and ſolid veſſels, wherein he uſed to keep his glaſs in fuſion, would, in the fire, ſcale or crack (and perhaps fly) and become unſerviceable no leſs than ſome weeks ſooner, than if they had never been impaired by the froſt. And when I inquired, whether alſo glaſs itſelf would not be much prejudiced thereby, he affirmed to me, that oftentimes in very hard froſts many glaſſes, that had continued entire for many weeks (for that circumſtance I was ſollicitous to aſk about) would as it were of their own accord crack with loud noiſes. But whatever prove to be the iſſue of ſuch trials, it will not be amiſs to confirm the phænomenon itſelf, by the teſtimony of an illiterate but very experienced French author, who, on a certain occaſion, tells us, (as I alſo take notice in another * treatiſe) 'That he 'knows the ſtones of the mountains of *Ardenne* (famous enough in *France*) are harder 'than marble, and yet the inhabitants of that 'country do not draw them out of the quarry 'in winter, becauſe they are ſubject to the 'froſt. And it has been divers times ſeen, 'that upon thaws, the rocks, without being 'cut, have fallen down and killed many.'

* *Of the imperfection of Phyſicks.* Maiſtre Bernard Paliſſy.

BUT it may yet ſeem far more unlikely, that froſts ſhould get into metals themſelves, and yet having aſked the newly-mentioned Polonian, whether he had obſerved any thing of that kind; he anſwered, that he had often by drawing out his ſword and pulling out his piſtols, when he had been long in the field, and came into a hot room, found them quickly almoſt whitened over, by a kind of ſmall hoar froſt. But whether this were, as he conceived, any thing, that was drawn out of the ſteel, and ſettled on the ſurface of it, I want circumſtances enough to make me willing to determine. But if we will credit *Olaus Magnus*, it muſt be confeſſed, that conſiderably thick pieces of iron and ſteel itſelf will, in the northern regions, be rendered ſo brittle by the extreme froſt, that they are fain to temper their inſtruments after a peculiar manner: his words, which being remarkable I forbear to alter, are theſe; *Videntur præterea ferrei ligones certa ratione fabricati, quia his ſpiſſa atque indurata glacies cæteris inſtrumentis ferreis non cedens faciliùs infringitur, dum aliæ ſecures chalybe permixtæ, in vehementi frigore ad ſolum glaciei vel virentis arboris ictum inſtar vitri rumpuntur, ubi ligones prædicti ſive ferreæ haſtæ fortiſſimi manent.* Which teſtimony, notwithſtanding what ſome have written to this author's diſparagement, does not ſeem to me at all incredible. For I remember, that even here in *England* I have had the curioſity to cauſe trials to be made in very froſty weather, whereby, if an expert ſmith I then uſed to employ, did not *gratis* deceive me in the irons I imployed, that metal may by ſuch degrees of cold, as even our climate is capable of, be rendered exceeding brittle, as he ſeveral times affirmed to me, that there are ſome kinds of iron, which he could hammer, and turn, as they phraſe it, cold in open weather, which yet in very hard froſts would become ſo brittle, as by the ſame way of working eaſily to break, if not to fly aſunder. And this he affirmed both of iron and ſteel; of which latter metal another very ſkilful workman, whom I alſo conſulted, certified the like: but though this diſagreed not with trials purpoſely made on iron rods, as they had informed me, yet preſuming, that in ſuch a nice piece of work as a ſpring, ſome further ſatisfaction about this matter might

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might be obtained, I inquired of a very dexterous artificer, that was ſkilled in making ſprings for others, whether or no he found a neceſſity of giving ſprings another temper in very froſty weather, than at other ſeaſons; and he anſwered me, that in ſuch weather, if he gave his ſprings the ſame temper, that he did in mild and open air, they would be very apt to break. And therefore in very ſharp ſeaſons he uſed to take them down lower, as they ſpeak, that is, give them a ſofter temper than at other times; which, as it makes it probable, that the cold may have a conſiderable operation upon bodies, upon which moſt men would not ſuſpect it to have one; ſo that diſcovery may afford a hint, that may poſſibly reach further than we are yet aware of, touching the intereſt, that cold may have in many of the phænomena of nature.

I SHOULD here ſubjoin, that in proſecution of what is delivered in the XXth ſection about the weight of ſolid bodies, that I there wiſhed might be expoſed to a congealing air, I did cauſe ſome trials of that kind to be made in a very froſty night, eſpecially with bricks; but ſomething, that happened to the only ſcales I then had fit for ſuch an experiment, made me doubt, whether ſome little increaſe of weight, that ſeemed to be gained by congelation, were to be relied upon, though there did not appear any hoar froſt, or other thing outwardly adhering, to which the effect could be aſcribed.

IT is a tradition, which the ſchools and others have received with great veneration from their maſter *Ariſtotle*, that hot water would ſooner freeze than cold; but I do not much wonder, that the learned *Cabæus*, as I find him quoted by *Bartholinus*, ſhould contradict this tradition, though he be himſelf a commentator upon that book of *Ariſtotle*, wherein it is delivered. For I could never ſatisfy myſelf, that there is (at leaſt without water, and in our climate) any truth in the aſſertion, though I have made trial of it more ways than one; but it may very well ſuffice to mention a few of the plaineſt and eaſieſt trials, with whoſe ſucceſs I am well ſatisfied as to the main, as the reader alſo will, I doubt not, be; though not having, for want of health, been able to have ſo immediate an inſpection of theſe, as of the reſt of my experiments, I was fain to truſt the watchfulneſs of my ſervants (whom I was careful to ſend out often) to bring me word, how long after the firſt freezing of the cold water, it was before the other began to be congealed.

WE took then three pottingers, as near of a ſize as we could; and the one we filled almoſt to the top with cold water, the other with water, that had been boiled before, and was moderately cooled again, and the third with hot water: theſe three veſſels were expoſed together in the ſame place to the freezing air.

IN the entry of one of the trials, I find, that being all three put out at half an hour after eight of the clock, the pottinger, that contained the cold liquor, began to freeze at $\frac{1}{4}$ after ten.

THAT, which contained the water heated and cooled again, began to freeze $\frac{3}{4}$ paſt ten.

AND that, which contained the hot water, at half an hour after eleven, and ſomewhat better. So that though all froze within the compaſs of two hours, yet the cold water began this time to freeze an hour and $\frac{1}{4}$ ſooner than the hot.

THESE pottingers were earthen, but I elſewhere made the trial of others of metal, and there alſo the cold water began to freeze, both before that, which had been heated and cooled again, and long before the hot.

ANOTHER time I meaſured out the water by ſpoonfuls into pottingers (not having then by me any fit ſcales to weigh it) to be the more ſure, that the quantities of water ſhould not be conſiderably unequal, and then alſo the cold water froze a conſiderable while before the hot.

BUT my uſual jealouſy in the making nice experiments tempting me to enquire, whether the water in ſome of the former trials had not been heated in a ſtone bottle, nor a ſkillet, it was confeſſed, that it was ſo, but that the bottle uſed to contain nothing but beer, and had been waſhed before-hand: and though I did not think, that the bottle could have any conſiderable influence on the experiment; yet leſt it ſhould be ſuſpected, that the ſcalding water might have imbibed ſome ſpirituous parts remaining yet among the minute dregs of beer in the pores of the bottle, for the greater ſecurity I cauſed the water to be heated in a ſkillet; and becauſe in one of the trials made in a village, where we had not choice of pottingers, the cold water chanced to be put into one, that afterwards ſeemed leſs, than that wherein the hot was expoſed, I did this very day repeat the experiment, by putting the cold water into a ſomewhat larger pottinger, heating the other water in a ſkillet, and the event of the trial is this;

THAT the cold water being put out with the reſt, at $\frac{3}{4}$ after 6, began to freeze ſomewhat before $\frac{1}{2}$ after 7.

THE water heated and cooled again began to freeze $\frac{1}{4}$ after 7. And having theſe frozen waters a little while by me, I ſent in, for my own further ſatisfaction, for the hot water, and found it not to be, in the leaſt, frozen at half a quarter after eight. So that ſuppoſing it to continue half a quarter of an hour longer before the beginning of its congelation *, it was twice as long ere it began to freeze, as the cold water had been.

* *As it afterwards did at the leaſt.*

BY which we may ſee, how well beſtowed their labour hath been, that have puzzled themſelves and others, to give the reaſon of a phænomenon, which perhaps with half the pains they might have found to be but chimerical.

I HAVE been the more circumſtantial in ſetting down theſe trials, that I may expreſs a civility to ſo famous a philoſopher as *Ariſtotle*; and alſo becauſe artificial congelations, which we can commonly beſt command, and which we have the oftneſt uſed about our other experiments, are not ſo proper for this. For having formerly had the curioſity to take two pipes of glaſs made of the ſame cylinder, that

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they might be of equal bore, and having sealed each of them at one end, and having filled both to the same height, and then stirred them to and fro together in a mixture of beaten ice, water and salt, (which mixture I make use of for the effecting sudden congelations) I found both waters to freeze too quickly to make a notable disparity in the length of times, that they remained uncongealed: and we will not, on this occasion, omit one phænomenon afforded us by these trials, because it may admonish men, how cautious they ought to be in making nice experiments. For having once made the formerly mentioned trial, with glass pipes, that were but slender (as not exceeding the bigness of a man's fore-finger) and having for greater caution put the hot water first into one glass, and then into another, we found one time, that the hot water froze first, and wondering at it, we examined the glasses, and perceiving one of them to be more conical or acuminated, where it had been sealed up, than the other, it seemed probable, and afterwards appeared true, that the water in this acuminated part, being suddenly frozen by reason of the slenderness of the glass there, promoted and accelerated the congelation of the rest; so that whether it were the cold or the hot water, that was put into that pipe, it would thereby gain a manifest advantage.

In the foregoing experiments (made in pottingers) I made use not only of cold and hot water, but of water that had been heated and cooled again, though not reduced to its full pristine coolness, to prevent the objections of some, that might pretend, that such water would have frozen sooner than cold, which yet would not solve the common opinion which specifies not such water.

POSTSCRIPT.

And it seems, that such cautions, as I have been mentioning, are not altogether useless. For accidentally casting my eye upon the *Circulus Pisanus* of *Berigardus* upon *Aristotle*'s meteors, I somewhat wondered to find, that an author, who is looked upon to be a great adversary of *Aristotle*, except in his dangerous and ill-grounded conceit of the eternity of the world, and some other erroneous opinions, does yet endeavour to justify *Aristotle* by affirming, that this experiment will succeed, if by heated water we understand that, which having been heated, is suffered to cool again, till it be reduced to the temper of other water, which was not heated. For this refrigerated water, he says, he has found to congeal much sooner than the other water: but this I confess I am very unapt to believe. For having divers times caused cold water to be exposed to the air in frosty weather, with that, which had been heated and cooled again, and having set sometimes one of my domesticks, sometimes another, to watch them, the events did very much disfavour the assertion of our author, though care was had of the circumstances most considerable in such an experiment, as the matter, size and shape of the vessels; the equal degree of cold in the two several parcels of water (into both which I sometimes dipped my finger to judge of them before they were exposed) and the place, in which they were put both together to be frozen. But for further satisfaction, we elsewhere took two pottingers, bought purposely for the making of experiments, of the same size and shape, and in the same shop: one of these we almost filled with cold water out of a glass, wherein we marked, how high that water reached, that by filling the same glass to the same height with the refrigerated water, we might be able to measure out the same quantity into the other pottinger. This done, I appointed one, whose care I had no reason to distrust, to examine the tempers of these several waters, with a more than ordinarily sensible weather-glass, as a far safer criterion, than the bare touch, to judge of the coldness of liquors. These being reduced to the same temper, were exposed to a very sharp air, and there watched by the person, whom (being not well, and unable to support such weather my self) I appointed to attend the experiment, and he, according to direction, finding them begin to freeze, as it were at the very same time, brought me in the two pottingers, in each of which I saw the beginnings, and but the beginnings of congelation, where the upper surfaces of the waters were contiguous to the containing vessels. So that having made this experiment with much greater exactness than probably *Berigardus* did, or, for want of such instruments as I used, could make it, I cannot but suspect, supposing the common waters, he and I used, to be of the same nature, that he was either negligent or over-seen in affirming, that heated and refrigerated water will cool so much sooner*. And as I am not convinced by experience, that it will freeze sooner at all, so till he have better made out the reason he seems to give of the phænomenon, I must question, whether he rightly ascribe after *Cabæus* (if I much misremember not) the congelation of water to a certain coagulum, distinct from the cold spirits, that plentifully mingle with the water, which coagulum it seems (for his style is not wont to be very perspicuous) that he would have to consist of certain dry corpuscles, no less necessary to conglaciate water, than runnet to curdle milk: and for what this author says †, that he must have employed boiling or scalding water, who affirms it to be less congealable than other, that mistake may be sufficiently disproved by the several above recited trials, wherein we found water, moderately refrigerated, to freeze much later than cold. And whereas *Berigardus* intimates, that the person, whosoever he be, that he dissents from, does unskilfully suppose warm salt-water to be the less disposed to congelation for being salt, our author is therein also mistaken; for though it be true, what he alledges, that salt outwardly applied promotes the congelation of water, yet

* *Quæ refrigerantem aquam adhibuisse oportet qui asserit eam esse minus gelabilem, præcipuè salsam,* pag. 571.

† *Tam cito illa congelabat, ut eximirem ex eo crustam unam aut alteram antequam non calefacta vel levissime concrevisset,* pag. 572.

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yet that, diſſolved in water, has a contrary effect, may appear by the familiar obſervation, that ſea-water is more difficult to be congealed than freſh water. And to ſhew, that it is not a property of ſea-water, but a water impregnated with common ſalt, I have ſeveral times tried, that a ſtrong ſolution of ſuch ſalt in ordinary water, will not at all be congealed by the being expoſed to the air, even in very ſharp froſts; as may be eaſily collected from ſome of the experiments mentioned in the former part of this book. Another particular there is (about the uſe of alum in reference to freezing) in this often-cited paſſage of *Berigardus*, which I might here examine, if my haſte and my indiſpoſedneſs to ingage in a controverſy of ſmall moment, did not injoin me to defer it till a fitter occaſion.

Here the poſtſcript ends.

To confirm the power aſcribed in the ſixth ſection to cold, as to the long preſervation of bodies from corruption, it will not be amiſs to add theſe two remarkable paſſages, the latter of which affords a good inſtance of the improvement, that may be made of ſome degrees of cold to the uſes of human life.

THE firſt obſervation is afforded us by ſome of our country-men, in a voyage extant in *Purchas*, where the writer of it ſpeaks thus, of the Samojeds, whoſe country he viſited: *Purchas*, lib. 4. cap. 19. pag. 844. 'Their dead they bury on the ſide of the hills, 'where they live (which is commonly on 'ſome ſmall iſlands) making a pile of ſtones 'over them, yet not ſo cloſe, but that we 'might ſee the dead body, the air being ſo 'piercing, that it keepeth them from much 'ſtinking ſavour: ſo likewiſe I have ſeen 'their dogs buried in the ſame manner.'

THE other obſervation is given us in the deſcription of *Ireland* (made by one that viſited it) to be met with in the ſame *Purchas*'s collections, where among other things he gives us this account; which, if I miſtake not, I have had confirmed by others, of their ſtrange way of ordering and preſerving their fiſh. Lib. 3. cap. 22. 'Having taken them, they pluck out the bones, 'and lay up their bowels, and make fat or oil 'of them. They heap up their fiſh in the 'open air; and the purity of the air is ſuch 'there, that they are hardened only with the 'wind and ſun, without ſalt, better ſurely 'than if they were corned with ſalt. And 'if they kill any beaſt, they preſerve the fleſh 'without ſtink or putrefaction, without ſalt, 'hardened only with the wind.'

I KNOW not, whether it will be worth while to add to the fifth and ſixth numbers of the ſeventh title, that, for further confirmation of our opinion, that it is not nature's abhorrency of a vacuum, but the diſtenſion of the water, that breaks glaſſes, when the contained liquors come to be congealed, I did on ſet purpoſe fill ſeveral phials (ſome at one time, and ſome at another) to the lower parts of their necks (moſt of which were purpoſely made long) with common water, and though they were all left unſtopped, that the external air might come in freely to them; yet not only one of them, that I ſtirred up and down in a mixture of beaten ice, ſalt, and water, was haſtily broken upon the congelation of the contained water, but ſeveral others, that were expoſed to be frozen more leiſurely by the cold air only, were likewiſe broken to pieces, by the expanſion of the freezing water, as appeared both by the gaping cracks, and alſo by this, that the ice was conſiderably riſen in the necks above the water's former ſtations, which had been noted by marks before; and if it had been more eaſy for the included water to make it ſelf room, either by ſtretching the glaſs, or (rather) leaving the ſuperficial ice congealed at firſt in the neck, or by both thoſe ways together, than to break the veſſel, the phial would probably have remained intire.

I SAY probably, becauſe I am not ſure, that there may not ſometimes intervene, in theſe experiments, ſomewhat, that may need further obſervation and inquiring. For as it ſeems, that what I have been lately ſaying may be confirmed by an unſtopped phial, which was expoſed at the ſame time to congelation, with this ſucceſs, that without breaking the phial the water was frozen, and the ice in the neck impelled up a good way above the height, at which the liquor reſted before it began to congeal; ſo, on the other ſide, I remember, that I have ſometimes had a good ſtore of liquor frozen in a phial, without breaking the glaſs, though a phial were ſtopped: as if the difference, that I have on other occaſions obſerved betwixt glaſſes, whereof ſome are very brittle, and others more apt to yield, might have an influence on ſuch experiments, or that ſome peculiar ſoftneſs, or other property of the ice, that afforded me my obſervation, or elſe ſome other thing not yet taken notice of, were able to vary their ſucceſs.

IN confirmation of what is delivered in the ſeventh ſection, about the expanſion of water by freezing, I ſhall add, that having cauſed ſome ſtrong glaſs-bottles of a not inconſiderable bigneſs to be filled with a congealable liquor, excepting the necks, which were filled with ſallet-oil, I obſerved, that in a ſomewhat long, and very ſharp froſt, the contained water was ſo far expanded by congelation, that it not only thruſt up the corks, but the cold having taken away the defluency of the oil, that liquor together with the water, that could no longer be contained in the cavities of the glaſſes, being, as it ſeemed, frozen as faſt as it was thruſt out of the neck, there appeared quite above the upper part of the bottles, cylinders of divers inches in height, conſiſting partly of concreted oil, and partly of congealed water, having on their tops the corks, that had been raiſed by them.

IT is a tradition very current among us, that when ponds or rivers are frozen over, unleſs the ice be ſeaſonably broken in ſeveral places, the fiſhes will die for want of air *. And I find

* *Volentes igitur piſcari ſub glacie duo magna foramina, latitudine* 8. *vel* 10. *pedum centum & quinquaginta vel* 200. *paſſibus à ſe invicem directa diſtantia, aperiunt, inter quæ* 30. *vel* 40 *minora foramina, latitudine unius pedis & ſemis, ab utroque latere diſtantia* 30. *pedum intermedia conſtituunt, tum per ea, &c.* Olai Mag. lib. 20.

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find this tradition to be more general, than, before I made particular enquiry into it, I knew of. For *Olaus Magnus* mentions it more than once, without at all queſtioning the truth of it, but rather, as if the general practice of the northern nations to break in divers places their frozen ponds and rivers, were grounded upon the certainty of it. In the twentieth book (which treats of fiſhes) after having ſpoken of the reaſons, why the northern fiſhermen employ ſo much pains and induſtry to fiſh under the ice; and having ſaid among other things, that the nature of the fiſh exacts it, he adds this reaſon, that, * *Niſi glacie perforata reſpiracula ſuſciperent, quotquot in flumine vel ſtagno verſantur, ſubito morerentur.* Another paſſage of the ſame author, and taken likewiſe out of the ſame (20th) book you may meet with in the margin, though in another place he ſeems to intimate another, and not an abſurd, reaſon of the death of fiſhes in winter; where advertiſing the reader, that ponds and lakes did generally begin to freeze in † *October*, he adds, that fiſhes are uſually found ſuffocated, when the thaw comes, where veins (or ſprings) of living water do not enter: by which paſſage he ſeems to make the want of ſhifted water co-operate to the ſuffocation of the fiſhes. And to the ſame purpoſe I ſhall now add, that having enquired of a learned native, that had lived about *Cracovia*, (whoſe territory is ſaid to abound much in ponds) whether the Polanders alſo uſed the ſame cuſtom; he anſwered me, that they did, and that ſometimes in larger ponds they were careful to break the ice in eight or ten ſeveral places, to make ſo many, either vents or air-holes, for the preſervation (as they ſuppoſed) of the fiſh. And when I inquired of the often-mentioned Ruſſian emperor's phyſician, whether in *Muſcovy* the froſt killed the fiſh in the ponds, in caſe the ice were not broken to give them air; he anſwered, that in ordinary ponds it were not to be doubted, but that in great lakes he could not tell, becauſe the fiſhermen uſed to break many great holes in the ice for the taking of the fiſh. For at each of theſe holes they thruſt in a net, and all theſe nets are drawn up together in one great breach made in ſome convenient place near the middle of the reſt.

IT appears then, that the tradition is general enough; but whether it be well grounded enough, I dare not determine, either affirmatively or negatively, till trial have been made in ponds with more of deſign or of curioſity, and watchfulneſs, than I have known hitherto done; men ſeeming to have acquieſced in the tradition without examining it, and to have been more careful, not to omit what is generally believed neceſſary to the preſervation of fiſh, than to try, whether they would eſcape without. Wherefore, though, for aught I know, the tradition may prove true, yet to induce men not to think it certain, till experience has duly convinced them of it, I ſhall repreſent, that as much as I have in other treatiſes manifeſted how neceſſary air is to animals; yet whether fiſhes may not live, either without air, or without any more of it, than they may find interſperſed in the water they ſwim in, has not yet, that I know of, been ſufficiently proved. For what we have attempted of that nature, in our pneumatical engine, whether it be ſatisfactory or not, is not yet divulged. And I remember not to have hitherto met with any writer, (except *Olaus* be conſtrued to intimate ſo much) that affirms upon his own obſervation, that the want of breaking ice in ponds has deſtroyed all the fiſh. Beſides, that poſſibly in frozen ponds, there may be other reaſons of the death of fiſhes, that there are killed (if any ſtore of them be ſo) by very ſharp froſt. For who knows what the locking up of ſome kinds of ſubterraneal ſteams, that are wont freely to aſcend through water unfrozen, may do to vitiate and infect the unventilated water, and make it noxious to the fiſhes, that live in it? perhaps alſo the excrementitious ſteams, that inſenſibly iſſue out of the bodies of fiſhes themſelves, may, by being penned up by the ice, contribute, in ſome caſes, to the vitiating of the water, at leaſt in reference to ſome ſort of fiſhes. For being deſirous to learn from a perſon curious of the ways of preſerving and tranſporting fiſh, whether ſome fiſhes would not quickly languiſh, grow ſick, and ſometimes die out-right, if the water they ſwam in were not often ſhifted, he aſſured me, that ſome kinds of them would: and it has not yet, that I hear of, been tried, whether or no, though ponds ſeldom freeze to the bottom, yet the water, that remains under the ice (in which itſelf ſome fiſhes may be now and then intercepted) may not, even whilſt it continues uncongealed, admit a degree of cold, that though not great enough to turn water into ice, may yet be great enough, when it continues very long, to deſtroy fiſhes, though not immediately, yet within a leſs ſpace of time, than that, during which the ſurface of the pond continues frozen. But it is not worth while to be ſolicitous about conjectures of cauſes, till we are ſure of the truth of the phænomenon; and theſe things are propoſed not ſo much to confute the tradition, we have been ſpeaking of, as to bring it to a trial, which, having no opporutnities to make in ponds, I endeavoured, as well this winter as formerly, to obtain what information I could from trials made in ſmall veſſels, with the few fiſhes I was able to procure. And I ſhall ſubjoin moſt of theſe trials, not becauſe I think them very conſiderable, but becauſe they are, for aught I know, the only attempts of the kind, that have yet been made.

To ſatisfy myſelf, whether the ice's denying acceſs to the air was that, which deſtroyed fiſhes in frozen ponds, I thought upon this expedient;

* *Olaus Mag. Titulo, De curſu glaciali, pro piſcibus. Quæ* (Anguillæ) *ſi totaliter glacie conſtrictæ fuerint, ſimul omnes reſpiraculum ab aëre non habentes pariter ſuffocatæ moriuntur.*

† *Præmittendum eſt quod generaliter omnes lacus & ſtagnales aquæ in menſe Octobri incipiunt congelari, glacieſque multo frigore in pleriſque locis tantum condenſari, ut ubi venæ lacu & ſtagno viventis aquæ non intrant, piſces ſuffocati tempore reſolutionis glaciei inſpiciantur; verum ne hæc ſuffocatio tam diſpendioſa fiat, diligentiâ piſcatorum continue glacies ipſa perfringitur, ne congeletur.* Olai Magni, lib. 1. Titulo de tranſitu glaciali, &c.

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pedient; I procured a glaſs veſſel with a large belly, and a long neck, but ſo ſlender, that it was only wide enough for the body of the fiſhes to paſs through: and then having filled the veſſel with ſome live gudgeons, and a good quantity of water, the neck of it was made to paſs through a hole, that was left, or made for it in the midſt of a metalline plate, or wooden trencher, which could deſcend no lower than the neck, becauſe of the inferiour part of the glaſs, that would not ſuffer it, and which ſerved to ſupport a mixture of ice (or ſnow) and ſalt, which was applied round about the extant neck of the glaſs. By this contrivance I propoſed to myſelf a double advantage: the firſt, that, whereas in broad veſſels it is not always ſo eaſy, as one would think, to be ſure, that the ſurface of the water is quite frozen over in every part; by this way I could eaſily ſatisfy myſelf, by inverting the glaſs, and obſerving, that the ice had ſo exactly choaked up and ſtopt the neck, that no drop of water could get out, nor any bubble of air get in, and yet the fiſhes had liberty enough to play in the ſubjacent water. The other conveniency was, that the frigorifick mixture being applied to the neck, no water was congealed, or extremely refrigerated, but that, which was contained in the neck; ſo that there ſeemed no cauſe to ſuſpect, that in caſe the fiſhes, thus debarred of air, ſhould not be able to live in the water, it was rather cold, than want of air, that killed them. But though not having then been able, by reaſon of a remove, to proſecute theſe trials to the utmoſt, nor to regiſter all the circumſtances, I ſhall not lay much weight upon it; yet I remember, that the included fiſhes continued long enough alive, to make me ſhrewdly ſuſpect the truth of the vulgar tradition.

ANOTHER time being deſtitute of the conveniency of ſuch glaſſes, I cauſed ſome of the ſame kind of fiſhes to be put into a broad and flat earthen veſſel, with not much more water, than ſufficed perfectly to cover them; and having expoſed them all night to a very intenſe degree of cold, I found the next morning, that ſome hours after day, they were alive, and ſeemed not to have been much prejudiced by the cold, or excluſion of air. It is true, that there was a very large moveable bubble under the ice; but that ſeemed to have been generated by the air, or ſome analogous ſubſtance, emitted out of the gills or bodies of the fiſhes themſelves: for, that the ſurface of the water was exactly frozen over (which does not in ſuch trials happen ſo often, as one would think) I found, by being able to hold the veſſel quite inverted, without loſing one drop of water. And that this large bubble might poſſibly proceed from the fiſhes themſelves, I was induced to ſuſpect, becauſe having at different ſeaſons of the year, for divers purpoſes, kept ſeveral ſorts of fiſhes, and particularly gudgeons, for many days in glaſs veſſels, to ſatisfy myſelf about ſome phænomena I had a mind to obſerve, I have often, by watching them, ſeen them lift up their mouths above the ſurface of the water, and ſeem to gape and take in air, and afterwards let go under water out of their mouths and gills divers bubbles, which ſeemed to be portions of the air they had taken in, perhaps a little altered in their bodies. And particularly in lampreys (of which odd ſort of fiſhes I elſewhere make mention) I have, with pleaſure, both obſerved and ſhewed to ingenious men, that being taken out of the water into the air, and then held under water again, they very manifeſtly appeared to ſqueeze out, and that not without ſome force, at thoſe ſeveral little holes, which are commonly miſtaken for their eyes, numerous and conſpicuous bubbles of air, which they ſeemed to have taken in at their mouths, if not alſo at thoſe holes. But of theſe matters, a fitter occaſion may perhaps invite me to ſay more. To return now to our gudgeons, I ſhall add, that to ſatisfy myſelf further, what cold and want of air they may be brought to ſupport, I expoſed a couple of them in a baſon, to an exceeding bitter night; and though the next day I found the ice frozen in the veſſel to a great thickneſs, and one of the fiſhes frozen up in it, there remaining a little water unfrozen, the other fiſh appeared through the ice to move to and fro; and the ice being afterwards partly thawed, and partly broken, not only that fiſh was found lively enough, but the other, which I alone judged not to be quite dead, though, when the ice was broke, it lay moveleſs, did, in a few minutes, ſo far recover, as to tow after it (if I may ſo ſpeak) a good piece, into which his tail remained yet inſerted. And though one of theſe, and ſome other gudgeons, that had been already weakened by long keeping, were once more expoſed in the baſon to the froſt, and ſuffered to lie there, till they were frozen up; yet the ice being broken, in which they were incloſed, though their bodies were ſtiff and crooked, and ſeemed to be ſtark dead, lying in the water with their bellies upwards, yet one of them quickly recovered, and the other not very long after began to ſhew manifeſt ſigns of life, though he could not in many hours after ſo far recover, as to ſwim with his back upwards. It is true, that theſe fiſhes did not long ſurvive; but of that, two or three, not improbable reaſons, might be given, if it were worth while to name here any other than this, that the ice, they had been frozen up in, or the violence, that was offered them by the fragments of it, when it was broken, had wounded them, as was manifeſt enough by ſome hurts, that appeared upon their bodies; yet ſome other gudgeons were irrecoverably frozen to death, by being kept incloſed in ice, during (if I miſremember not the time) three days. And as for other animals, I cauſed a couple of frogs to be artificially frozen in a wide-mouthed glaſs, furniſhed with a convenient quantity of water: but though they ſeemed at firſt incloſed in ice, yet looking nearer, I found, that about each of them there remained a little turbid liquor unfrozen, as if it had been kept ſo by ſome expirations from their bodies. Wherefore cauſing either the ſame, or two others, (for I do not punctually remember that circumſtance) to be carefully frozen, and for a conſiderable while, I

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found, that notwithſtanding the ice, into which moſt part of the water was reduced, not only one of them before the ice was broken appeared to be perfectly alive, but the other, that was moveleſs and ſtiff, and lying with the belly upwards in a baſon of cold water, whereinto it was caſt, did in a very few minutes begin to ſwim about in it. I ſhould have made more trials at leaſt, if not alſo more ſatisfactory ones, if I could have had fiſhes, and veſſels, and cold weather at command: but upon the whole matter, though the tradition, we have been examining, may perhaps have ſomething of truth in it, yet it ſeems to deſerve to be further inquired into, both in reference to the truth of the matter of fact, *the death of fiſhes in frozen ponds and rivers*, and in reference to the cauſe, whereto that effect is imputed.

I MET with an odd paſſage in Captain *James*'s voyage, which, if it had been circumſtantially enough ſet down, might prove of moment in reference to the weight of bodies frozen and unfrozen; and therefore, though I would not build any thing on it, yet I ſhall not omit it. 'The ninth (ſays he, pag. 82.) 'we hoiſted our beer and cyder, and made a 'raft of it, faſtning it to our ſhoar-anchor. 'The beer and cyder ſunk preſently to the 'ground; which was nothing ſtrange to us, 'for that any wood or pipe-ſtaves, that had 'lain under the ice all winter, would alſo ſink 'down ſo ſoon as ever it was heaved over 'board.'

ABOUT the duration of ice I forgot, through haſte, to add a relation of Captain *James*'s, whereby it may appear, that though wine abounds with very ſpirituous and nimble parts, whence it reſiſts congelation far more than water, yet if even this liquor came once to be congealed, the ice made of it may be very durable. For he ſets down in his journal, that when he came to his ſhip again, he found a butt of wine, that had been all the winter in the upper deck, 'to continue as yet all firm frozen, though it 'were then the month of *May*. (*pag.* 47.)

WHEN I treated of the great proportion in ſome pieces of ice, that were aground, inſtead of taking notice of a great piece of ice mentioned by *Gerat de Veer*, to be 52 fathom deep, the paſſage, that was to be tranſcribed, was this other, hard by, which contains two examples of towers of ice, where the extant part reached upwards more than half as much as the immerſed part reached downwards. 'We ſaw '(ſays he) another great piece of ice not far 'from us, lying faſt in the ſea, that was as 'ſharp above, as if it had been a tower; where-'unto we rowed, and caſting out our lead, 'we found that it lay 20 fathom faſt on the 'ground under the water, and 12 fathom a-'above the water.—We rowed to another 'piece of ice, and caſt out our lead, and 'found that it lay 18 fathom deep, faſt on the 'ground under the water, and 10 fathom a-'bove the water.'

Purchas, lib. 3. cap. 5. pag. 487.

THAT ſnow lying long, and too long on the ground, does much conduce to the fertilizing of it, is a common obſervation of our huſbandmen. And *Bartholinus* in his treatiſe of the *uſe of Snow*, brings ſeveral paſſages out of authors to make it good: to which I ſhall add the teſtimony of our learned Engliſh ambaſſador, Dr. *Fletcher*, who ſpeaking of the fruitfulneſs of the ſoil, and haſty growth of many things in the great empire of *Ruſſia*, gives this account of it.

'THIS freſh and ſpeedy growth of the ſpring 'there ſeemeth to proceed from the benefit 'of the ſnow, which all the winter time being 'ſpread over the whole country, as a white 'robe, and keeping it warm from the rigour 'of the froſt, in the ſpring-time (when the 'ſun waxeth warm, and diſſolveth it into 'water) doth ſo throughly drench and ſoak 'the ground, that it is ſomewhat of a ſlight 'and ſandy mold, and then ſhineth ſo hotly 'upon it again, that it draweth the herbs and 'plants forth in great plenty and variety, in 'a very ſhort time.'

Purchas, lib. 3. cap. 1. pag. 415.

As we made ſome trials to diſcover, whether congelation would deſtroy or conſiderably alter the odours of bodies; ſo we had the like curioſity in reference to divers other qualities, not only thoſe, that are reputed manifeſt, as colours and taſtes, the latter of which we ſometimes found to be notably changed for the worſe in fleſh congealed, but alſo thoſe, that are wont to be called occult: and among the qualities of this ſort, I had particularly a mind to try, whether the purging faculty of catharticks would be advanced or impaired, or deſtroyed by congelation; and for this purpoſe I cauſed to be expoſed thereunto divers purging liquors, ſome of a more benign, and ſome of a briſker nature, and that in differing forms, as of ſyrup, decoction, infuſion, *&c.* But for want of opportunity, to try upon the bodies of animals, what change the cold had made in the purging liquors, it had congealed, I was unable to give my ſelf an account of the ſucceſs of ſuch experiments. Only ſince, in ſome of theſe trials I had a care to make uſe of cathartick liquors prepared by fermentation, (which way of preparing them is it ſelf a thing I elſewhere take notice of, as not unworthy to be proſecuted;) I ſhall add on this occaſion, that fermentation is ſo noble and important a ſubject, that the influence of cold upon it may deſerve a particular inquiry. And I am invited to think, that that influence may be very conſiderable, partly by my having obſerved (upon a trial purpoſely made) both that raiſins and water, (with which I was uſed to make artificial wines) did not in many days, whilſt the weather was very froſty, ſo much as manifeſtly begin to ferment, though the water were kept fluid; and partly by my having obſerved, that beer will continue as it were new, and be kept from being, as they call it, ready to drink, much longer than one would readily ſuſpect, if very froſty weather ſupervene, before it have quite finiſhed its fermentation; inſomuch, that an experienced perſon, of whom I afterwards inquired about this matter, aſſured me, that beer not duly ripe, would not ſometimes in five or ſix weeks of very froſty weather, be brought to be as ripe as in one week of warm and friendly weather. But we have a nobler inſtance

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inſtance to our preſent purpoſe, if that be true, which I learned from an intelligent Frenchman, whom I conſulted about this matter. For, according to this experienced perſon, the way to keep wine in the muſt (in which ſtate, its ſweetneſs makes it deſired by many) is to take newly expreſſed juice of grapes, and having turned it up before it begins to work, to let down the veſſels (which ought to be very carefully cloſed) to the bottom of ſome deep well or river, for ſix or eight weeks, during which time the liquor will be ſo well ſettled (if I may ſo ſpeak) in the conſtitution, it has ſo long obtained, that afterwards it may be kept in almoſt the ſame ſtate, and for divers months continue a ſweet, and not yet fermented liquor; which ſome, in imitation of the French and Latins, call in one word, *Muſt*. And how, by the help of cold well applied, ſome other juices, that are wont to work early, and to be thereby ſoon ſpoiled, may be long kept from working, the reader may perchance learn in another treatiſe, to which ſuch matters more properly belong.

It is known, that the ſchools define cold by the property they aſcribe to it, of congregating both heterogeneous and homogeneous things. I thought it not amiſs to attempt the making ſome ſeparations in bodies by the force of cold. For if that hold true in this climate, which has been obſerved by travellers and navigators in northern regions, that men may obtain from beer and wine a very ſtrong ſpirit, and a phlegm by congelation; it ſeems probable, that in divers other liquors the wateriſh part will begin to freeze before the more ſpirituous and ſaline: and if ſo, we may be aſſiſted to make divers ſeparations, as well by cold, as by heat, and dephlegm, if I may ſo ſpeak, ſome liquors, as well by congelation as by diſtillation. But I doubt, whether the ordinary froſts of this country can produce a degree of cold great enough to make ſuch diviſions and ſeparations in bodies, as have been obſerved in the more northern climates. For though having purpoſely hung out a glaſs-bottle with a quart of beer in it, in an extraordinarily ſharp night, I found the next morning, that much the greateſt part of the beer being turned into ice, there remained ſomewhat nearer the middle, but nearer the bottom, an uncongealed liquor, which to me and others ſeemed ſtronger than the beer, and was at leaſt manifeſtly ſtronger than the thawed ice, which made but a ſpiritleſs, and, as it were, but a dead drink; yet in ſome other trials, my ſucceſs was not ſo conſiderable as ſome would have expected. For having put one part of high rectified ſpirit of wine to about five or ſix parts, if I miſremember not, of common water, and having put them into a round glaſs, and placed that in beaten ice and ſalt, though the mixture were in great part turned into ice; yet I could not perceive, that even two liquors ſo ſlightly mingled were any thing accurately ſever'd from one another, although once, to enable my ſelf the better to judge of it, the ſpirit of wine I employed was beforehand deeply tinged with cochineal; and therefore I the leſs wonder, that in claret wine I could not make any exact ſeparation of the red and the colourleſs parts: however, I thought it not amiſs to try, how far in ſome other liquors this way of ſeparating the wateriſh, and more eaſily congealable part from the reſt, would or would not ſucceed. And I remember, that a large glaſs veſſel, wherein ſpirit of vinegar was expoſed to the cold, a conſiderable part was turned into ice, whoſe ſwimming argued it to be lighter than the reſt of the liquor. But though I put ſome of this ice in a glaſs by it ſelf, to examine by its weight and taſte, when thawed, how much it differed from the uncongealed part of the ſpirit, my hopes were diſappointed by a miſfortune, which was not repaired by my expoſing afterwards a ſmaller quantity of ſpirit of vinegar to the nocturnal air; for that proved ſo cold, that the whole was turned into ice: wherefore I muſt reſerve for another opportunity the proſecuting that experiment, as alſo the trying, whether a ſeparation of the ſerous or the oleaginous parts of milk may be effected. For though once the froſt ſeemed to have promoted a ſeparation of cream, notwithſtanding that the heat alſo may do it; and though another time there ſeemed to be another kind of divulſion of parts made by congelation; yet for want of leiſure to proſecute ſuch trials, they proved not ſatisfactory, no more than did ſome attempts of the like nature, that I made upon blood by freezing it. But notwithſtanding theſe diſcouragements, I reſolved to try, what I could do upon brine. For calling to mind the relations mentioned in the XVth title, and elſewhere, which ſeem to argue, that in ſome caſes the ice of the ſea-water may, being thawed, yield freſh water; and being the more inclined to think it worth trial, by a phyſician, I ſince happened to diſcourſe with about this matter, who affirmed to me, that ſailing along the coaſt of *Germany*, he had taken out of the ſea ice, that being thawed, he found to afford good freſh water; I began to conſider, whether we might not, by cold, free ſalt-water at ſome ſeaſons of the year from a great deal of the phlegm, which it is wont to coſt much to free it from by fire, and other means. For a little help towards the diminution of the freſh water is looked upon as ſo uſeful an experiment, by many, that boil ſalt out of the ſalt ſprings, that in ſome countries, that are thought the ſkilfulleſt in that trade, they make their ſalt-water fall upon great bundles of ſmall bruſh-wood, that being thereby divided, and reduced to a far greater ſuperficies, there may, in falling through, ſome of the purely aqueous parts exhale away: wherefore, diſſolving one part of common ſalt in forty-four times its weight of common water, that it might be reduced, either exactly, or near, to the degree of ſaltneſs, that has been by ſeveral writers obſerved in the water of our neighbouring ſeas, and having likewiſe cauſed another and much ſtronger brine to be made, by putting into the water a far greater proportion of ſalt, (for ſo there is in many of our ſalt ſprings) we expoſed theſe ſeveral ſolutions to the congealing cold of the air in froſty weather, where the laſt mentioned

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mentioned ſolution being too ſtrongly impregnated with the ſalt, continued ſome days and nights altogether uncongealed, but that weaker ſolution, which emulated ſea-water, being expoſed in a ſhallow and wide-mouthed veſſel, (that ſhape being judged the moſt proper we could procure for our deſign) the large ſuperficies, that was expoſed to the air, did, as we expected, afford us a cake of ice; which being taken off, and the reſt of the liquor expoſed again to the air in the ſame eſſel, we obtained a ſecond cake of ice: and taking the remaining, which ſeemed to be indiſpoſed enough to congelation, we found, that by comparing it with that, which was afforded us by the firſt cake of ice permitted to thaw, there appeared a very manifeſt difference betwixt the water, whereinto the ice was reſolved, ſcarce taſting ſo much as brackiſh; whereas the liquor, that had continued uncongealed, was conſiderably ſalt in taſte. And if I had had the conveniency of examining myſelf theſe two liquors hydroſtatically, as I was fain to have them examined by another, I doubt not but by their weight I ſhould have diſcovered preciſely enough the difference between them (which the perſon I employed found to be conſiderable) and conſequently ſhould have been aſſiſted to make an eſtimate of the advantage, that might be afforded by the operation of the cold towards freezing of the brine from its ſuperfluous water. But though I had not a quantity of ice great enough to ſatisfy me, whether that little brackiſhneſs of taſte, I have mentioned, proceeded from ſome ſaline corpuſcles, that concurred to the conſtituting of the ice itſelf, or did only adhere to the lower part of it, among other particles of the liquor, that remained uncongealed; yet perhaps it were not amiſs to try, whether in very large, though not deep veſſels, this experiment, eſpecially promoted by ſome expedients, that practice may ſuggeſt, may not, in ſome ſeaſons and places, be brought to be of ſome advantage.

WHILST I was endeavouring by ſome of the above-recited experiments, to make ſome ſeparations in liquors by congelation, I thought fit to try, by the ſame means, what ſeparations I could make in ſome bodies, betwixt liquors, and thoſe more ſtable parts, among which they were engaged; hoping, upon conſiderations, which it were too long to enumerate, that, if ſuch attempts ſhould ſucceed, they might afford hints of a luciferous nature. I took then divers vegetable ſubſtances of differing kinds, as turneps, carrots, beets, apples, and tender wood, freſhly cut off from growing trees; as alſo divers animal ſubſtances, as muſculous fleſh, livers, brains, eyes, tongues, and other parts, and expoſed them to a very ſharp cold, that they might be throughly frozen. Now one of the chief things, that I propoſed to myſelf in this attempt, was, to try, how far I could by congelation make diſcovery of any thing about the texture of animals and plants, that had not been taken notice of by anatomiſts themſelves, and would ſcarce otherwiſe be rendered viſible. And I eaſily found, that I had not groundleſly imagined, that in divers ſucculent bodies, both vegetable and animal, the ſap or the juice, that was ſo diſperſed among the other parts, and divided into ſuch minute portions, as not to be manifeſtly enough diſcriminated, might, by congelation, be both diſcerned and ſeparated from the reſt. For in divers plants, I found the alimental juice to be congealed into vaſt multitudes of diſtinct corpuſcles of ice; ſome of which, when the bodies were tranſverſly cut with a ſharp knife, and left a-while in the air, might be wiped or ſcraped off from the ſuperficies of the body, upon which it would after a while appear in the form of an efflorecence, almoſt like meal: but in others I took a better and quicker courſe, for by warily compreſſing the frozen bodies, I could preſently make the icy corpuſcles ſtart in vaſt numbers out of their little holes; and though ſome of theſe were ſo minute as to invite me to uſe a microſcope, that magnified a little, (not having then any of my beſt at hand) yet in ſome bodies, and eſpecially in carrots and beets, the icy corpuſcles were big enough to be diſtinctly or apart conſpicuous, inſomuch that I was not miſtaken in hoping, that the figures, as well as ſizes, (for as to the colour, it was ſcarce diſcernible in the ice, produced in ſo deeply crimſon a root, as the beet itſelf) of theſe little pieces of ice, might be gueſt at by the bigneſs and ſhape of the pores, that were left in the more ſtable part, or (if I may ſo call it) the parenchyma of the root; though in making an eſtimate of theſe cavites, as well as in diſcovering the order, wherein they are ranged, I found it uſeful to cut the frozen roots, ſometimes according to their length, and ſometimes quite croſs. For by that means there would appear in carrots, for example, of the larger ſort, a great diſparity in the order of the pores; which, when the root was divided by a plain parallel to the baſis, appeared placed in lines almoſt ſtrait, tending, almoſt like ſpokes of a wheel, from the middle to the circumference. But if the carrot were ſlit from one end towards the other, the icy corpuſcles and pores would ſeem ranged in an order, that would appear very differing, but which I have not now the leiſure to deſcribe; no more than what I obſerved with a microſcope, about the ice and pores of apples, the tongues of animals, chips of green and ſappy wood, *&c.* expoſed to congelation. Only this I ſhall not pretermit, that as I many years ſince made (and, as I now find, too freely communicated) an experiment (mentioned long after in other papers) of freezing the eyes of oxen, and other animals, whereby the ſoft and the fluid humours of that admirable organ may be ſo hardened, as to become tractable, even to unſkilful diſſectors; ſo I did, on this occaſion, apply that experiment to the brains of animals, which, though too ſoft to be eaſily diſſected, eſpecially by thoſe who are not dexterous, may, by congelation, be made very manageable by them: and beſides, that in diſſecting the hardened brain, it ſometimes ſeemed, that the knife did cut through multitudes of icy corpuſcles (as when one cuts a frozen apple) the ſubſtance of the brain ſeemed alſo to the

Of the Uſefulneſs of Experimental Philoſophy.

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eye to be ſtuffed with them, and the ventricles of it did at leaſt conſpicuouſly harbour pieces of ice, if it were not filled up with them. And the manifeſt difference of texture, that there is between the white and yolk of a throughly frozen egg, and alſo betwixt the cryſtalline and the aqueous, and the vitreous humours of the eye, wherein by congelation the cryſtalline alone loſes its tranſparency, but acquires no conſpicuous ice, whilſt the others are full of ice, and that diaphanous; theſe and ſuch like diſparities, I ſay, may invite one to hope, that ſome things may, by congealing of bodies, be diſcovered about their texture, that may afford ſagacious anatomiſts improvable hints.

I KNOW not, whether it will be thought worth while to take notice, that neither an eye, nor a liver, nor a lean piece of fleſh, nor a live fiſh, nor a living frog, being frozen and put into cold water, was obſerved to be upon its thawing caſed with ice, as frozen eggs and apples are wont to be; becauſe having forgot to make the experiment above once, I dare not much rely on it. But whereas we have formerly obſerved, that congelation does moſt commonly ſpoil, or at leaſt impair eggs, and apples, and fleſh, and many other bodies, I think it may not be unworthy to be conſidered, how far, and in what caſes we may give a mechanical account of this phænomenon. For though the immerſion of frozen bodies in cold water be allowed to thaw them, with leſs prejudice, than if they were thawed haſtily by the fire, or ſuffered to thaw themſelves in the air; yet there have been complaints made, that notwithſtanding this expedient ſeveral bodies have been much the worſe for having been thoroughly frozen, now ſince I have lately ſhewn, that in many ſtable bodies, the alimental juice is by congelation turned into ice, and have formerly evinced, that water and aqueous liquors are expanded by congelation, I ſee not, why we may not ſuſpect, that the innumerable icy corpuſcles, into which the alimental juice is turned by the froſt, being each of them expanded proportionably to their reſpective bigneſſes, may not only prejudice the whole, by having their own conſtitution impaired, as has been formerly obſerved in Alicant, and other vinous liquors, but may, upon their expanſion, cruſh in ſome places, and diſtend in others, the more ſtable parts, in whoſe cavities they were harboured; and thereby ſo vitiate their texture, as to impair ſome of their qualities, and diſpoſe the compoſitum to corruption. How much contuſion may prejudice tender bodies, and accelerate putrefaction, is evident in many fruits, eſpecially the more tender ones, which having been bruiſed, quickly begin to rot in thoſe parts, that have been injured. And it is agreeable to what has been formerly ſhewn, to conceive, that in congelation there ſeems to happen an almoſt innumerable multitude of little contuſions, made by the fluid parts hardened and expanded by froſt, of the formerly more ſtable parts every where intercepted between them: and though theſe icy corpuſcles be but ſmall, yet the ſides of that ſtable matter, that ſeparates them, and which they endeavour to ſtretch or cruſh, are oftentimes proportionably thin.

AND we have formerly noted, that, beſides that eggs will be burſt by having their alimental juice frozen, both ſhingles, and ſtones themſelves may have their texture ſpoiled by the congelation of the mineral ſap, that is in exceeding minute and inſenſible particles diſperſed through thoſe bodies: and the violation of the texture of plants, herbs, and animals, by the expanſion of the aqueous and juicy particles, which, though they be not congregated, do abound in them, will be the leſs wondered at, if it be remembered, that our former trials manifeſt, that a few ounces of water congealed did not only burſt glaſs and pewter veſſels, but even the iron barrel of a gun.

WHILST I was upon theſe trials, I had alſo a curioſity to know, whether by freezing animals to death, I could diſcover any ſuch change in the qualities or ſtructure of their parts, as might help us to diſcover, by what means it is, that exceſſive colds kill men in northern countries, ſince ſuch a diſcovery might probably be of good uſe to the people that live in thoſe gelid regions: but having taken a young rabbit, as the tendereſt and fitteſt beaſt, I could then procure for ſuch a trial, and having expoſed him all night to an extraordinarily bitter froſt, without finding him otherwiſe miſchiefed by it, than that one of his legs was ſwelled and grown ſtiff, I was more inclined to reſign over to others, than to repeat myſelf what ſeemed to be an ill-natured experiment, though perhaps it may have much leſs of cruelty than one would think, ſince ſome of our former obſervations have made it probable, that oftentimes the extinction of life by cold is a more indolent kind of death than almoſt any other. But in a rabbit purpoſely ſtrangled, and preſently expoſed intire to a bitter cold, we found ice produced in ſuch parts, as would have made us proſecute the trial, had the want of ſuch animals and of leiſure not hindered us.

IT is affirmed by divers eminent writers, and thoſe modern ones too, that water impregnated with the ſaline parts of the plants, and afterwards frozen, will exhibit in the ice, the ſhape of the ſame plant; and the learned, but I fear too credulous, *Gaffarel* tells us, that this is no rarity, being daily ſhewn by one *Monſieur de la Clave*. But to what we have already publiſhed in another treatiſe *, to ſhew that this experiment, as it is wont to be delivered, is either untrue, or very contingent; we ſhall need but to add, that, ſince the experiments there mentioned, we did again lately try, what could be done with decoctions, that were richly imbued, and highly tinged with the ſpirituous parts of the vegetables; but this ice was by no means ſo figured as the patrons of the tradition promiſe: and I remember, that having alſo made, for curioſity ſake, a lixivium with ſixteen parts of water, and but one of ſalt of potaſhes, that the mixture might be ſure to freeze; and having expoſed the liquor in a thin glaſs phial to an exceeding cold air, we found the copious ice produced to lie on

* *Of the Unſucceſsfulneſs of Experiments.*

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the top in little ſticks, not unlike thoſe priſmatical bodies, wherein ſalt-petre is wont to roch; and thoſe parts of this ice, that were beneath the water, were ſhot in thin parallel plates, exceeding numerous, but (as one of our notes expreſly informs us) no way in the ſhape of trees, by whoſe incineration nevertheleſs Polonian pot-aſhes (as eye-witneſſes, that deal in them, inform me) are made.

LONG after the making of the newly recited experiment, I chanced to find, that the learned *Bartholinus* in the treatiſe, we have often had occaſion to take notice of, ſays, '* That the 'water, wherein cabbage has been decocted, 'will, when frozen, repreſent a cabbage; the 'vegetable ſpirits being, as he ſuppoſes, con-'centrated by the cold.' How well this experiment may ſucceed, when made in a cold country like his, I do not know; but not having my ſelf, when I firſt took notice of it, the opportunity to try it ſatisfactorily by help of a froſty night, all I could do, was, to take a good decoction of cabbage, and filtrate it through cap paper, that it might be, though yellow, yet clear; and then by the circumpoſition of our frigorifick mixture, we froze this liquor in a thin glaſs phial, but the ice did not, either to me or others, appear to have any thing in it like a cabbage, or remarkably differing from other ice. And being afterwards befriended with two or three froſty nights, we expoſed a decoction of cabbage, to be congealed by the nocturnal air alone, without the help of art; but neither this way did the experiment ſucceed well. And tho' once a few ounces of the decoction being lightly frozen in a phial, there appeared in the thin ice, that adhered to the inſide of the glaſs, a figure not ſo very unlike that of a cabbage-leaf, but that ſome ſuch accident may have invited our learned author to think, that the repreſentations of cabbages would conſtantly appear in their frozen decoctions; yet I was inclined to think this figuration rather caſual, by the curioſity I have had to freeze the decoctions of ſeveral herbs, ſome of them ſpirituous enough, as roſemary, and penny-royal, without being able to find in the ice, I obtained from them, any conviction of the truth of the tradition we are examining. And I have lately had more than once, by freezing fair water alone, after a certain manner, ice, that ſeemed much more to exhibit the ſhapes of vegetables, than any decoctions of them, that I have made. And particularly I found more than once, that by putting hot water into a ſomewhat ſlender cylinder of glaſs, and agitating it in a frigorifick mixture, conſiſting of beaten ice, ſalt, and water, ſo that it was very ſpeedily frozen thereby, it was congealed into an ice much more regularly and prettily figured, than I have ſeen it in divers of the waters impregnated with the fixed ſalts of plants, though of theſe we are told ſuch wonders.

SUCH particulars as theſe, joined with what I have elſewhere obſerved to the ſame purpoſe, make me, I confeſs, ſomewhat ſurprized to meet in *Berigardus*'s forecited diſcourſe upon *Ariſtotle*'s meteors ſuch a paſſage as this; *Paucis notum eſt, cur intra glaciem cernuntur interdum multiformes ſtirpium imagines in ampullis vitreis, aquæ ſuperficie tenus congelatæ plenis. Hoc autem fit injecto in phialas ſale diverſarum ſtirpium, nam ubi erit ſal alicujus plantæ & artemiſiæ, in ſuo lixivio glacies adhærens vitro refert ejus folia lacinioſa: ſimiliter in alia phiala videbuntur folia plantæ, cujus ſal in ſuam aquam fuerit injectus. Et nè quis hoc fortuito cadere putet, in aquâ ſæpius ſolutâ & congelatâ eædem imagines ſemper occurrent, ut vel ex eo dixeris multiplicem ſpiritum ſalis in principiis naturalibus eſſe ponendum.* Pag. 5-3. Thus far this author, who would have done well, if he had been ſo much more lucky than other men, as to have performed theſe things, to aſſure expreſly of his having done ſo thoſe many ingenious men, that much diſtruſt the relations of thoſe chymiſts, that are not of the beſt ſort: and it is of ſuch ſuſpicious authors, that I here declare once for all, that I would have the reader underſtand all the paſſages of this book, wherein I may ſeem to ſay any thing (for avoiding of tediouſneſs) indefinitely to the diſparagement of chymiſts. And in caſe he had not tried them, he ſhould, in gratitude to the authors of them, have told us, he had, what he delivers of them, but from others, and not have authorized the untried reports of writers, not always too veracious, by his building theories upon them. And as for what he immediately ſubjoins, and ſeems to rely on, out of *Quercetan*, (and other ſpagyrical writers, who poſſibly had it themſelves from him) about the ſeminal virtues ſurviving in the aſhes of burnt plants; though I will not here examine, or abſolutely reject the opinion, becauſe the diſcuſſion of it belongs to another place; yet as to the experiment, whereon *Berigardus* and others rely, namely, that the lixiviums made of the aſhes of plants, will exhibit, being congealed, the figures of the priſtine vegetables; beſides that a general concluſion, as to other plants, ſeems to be inferred from what happened in nettles only, I much doubt, whether that famous experiment it ſelf of the frozen lixivium of nettles were more than caſual, if it were not alſo aſſiſted by an indulgent fancy. For having, after divers experiments made with other fixed ſalts, purpoſely repaired, for greater ſecurity, to the notedeſt chymiſt in *England*, to obtain from him ſome fixed ſalts, very faithfully prepared, and intimating withal, that it was to try ſuch an experiment (which he was a favourer of) I did, by mingling theſe ſalts each in a diſtinct phial, ſometimes with one, and ſometimes with another proportion of water, and afterwards expoſing them to the cold air, obtain indeed divers portions of ice, but without any ſuch figurations, as the learned *Berigardus* would have expected; though ſome of theſe trials were made more than once, as well with the lixivium of nettles, as with the lees of other plants. So that I doubt this author is more ſcrupulous in admitting ſome important truths,

* *Rem vero adeo obſcuram exemplis ſimilibus illuſtrabo braſſicæ: aqua congelata braſſicam repreſentat, ſpiritibus vegetalibus à frigore concentratis.* Tho. Bartholinus *de uſu nivis*, pag. 17.

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truths, in which the beſt philoſophers, as well heathen as Chriſtian, agree, than in examining the uncertain traditions of the chymiſts, whoſe unſatisfactory way of ſetting down matters of fact I am induced to take notice of his imitating, by finding, that in the very ſame page (that I have newly cited) he relates another chymical experiment in theſe terms: *Velim porro oſtendere mirabili experientiâ, quàm ſint penetrabiles aliqui ſpiritus corporei: exarentur in charta literæ, aceto albo, quarum nullum veſtigium deprehendatur, claudaturque primis foliis craſſiſſimi alicujus libri. Paretur alia charta, quæ inficiatur aqua illa fœtida, ubi dilutum fuerit auripigmentum, & exſiccata claudatur poſtremis foliis ejuſdem libri leviter compreſſi, ſtatim videbis in priori charta literas conſpicuas, perinde ac ſi atramento ductæ fuiſſent.* Now, though ſomething like what is here propoſed to be done, may be performed, and other phænomena of the experiment, ſuch as he ſeems not to have been acquainted with, may be alſo exhibited, after the manner I have * elſewhere particularly ſet down; yet he muſt have good luck, that performs it only by the directions here given by our author, who by omitting one of the chief ingredients, and ſome requiſite circumſtances, appears indeed manifeſtly enough to have heard of ſuch an experiment, but without ſeeming to have ſufficiently known, what he pretends to teach, (at leaſt as far as his bringing this experiment as a proof, and the obſcure ſtyle, he is wont to employ in the little I have yet read of his book, permits me to judge.)

* *In the unpubliſhed ſection of the Uſefulneſs of experimental philoſophy.*

But to return to the figurations of ice, notwithſtanding ſuch unſucceſsful trials about them, as I have been mentioning, I will not deny it to be poſſible, that a prepoſſeſſed and favourable ſpectator may think himſelf to have diſcerned in the ice, the figures he looked for there. For ſince the writing of the eſſay not long ſince quoted, we have found, that ſeveral bodies, and even ſea-ſalt, and alum, to whom nature has given their own determinate figures, have, when diſſolved in water, concurred with it to exhibit an ice very oddly, as well as prettily, figured, (nor will I preſume to determine the utmoſt, that a lucky obſerver may ſometimes meet with in this kind;) but to name at preſent no other arguments, the figures this way produced were too various and extravagant, not to be referred to chance, and not to afford inſtances, how much that can perform in the exhibiting of ſuch apparitions.

Of the Unſucceſsfulneſs of experiments.

On which occaſion I ſhall add, that I remember, I once ſhewed at the Royal Society a glaſs head, whoſe inſide was lined with a certain ſubſtance, that paſſed for ſaline, faſhioned into the figures of trees, as curious, as if they had been drawn by a limner: and yet as I produced theſe figures, only by rectifying common oil of turpentine, from ſea-ſalt (which ſalt I elſewhere ſhew not to be neceſſary) in a certain degree of heat; ſo by varying that degree of heat, I could make the aſcending ſteams ſettle in other figures. And I can eaſily produce very pretty ſhapes of trees by diſtillation of that, which belongs not to the vegetable, but the animal kingdom. And to theſe I could add divers other inſtances of the like tendency, to make it ſtill the more probable, that though oftentimes one may happen to find pretty ideas, or apparitions in ice; yet the like, or as fine, may be produced by chance. And I have ſometimes obtained by freezing infuſions, decoctions, ſpirits, ſolutions, and other liquors, as vinegar (and particularly) milk, and even common water, figures, that were ſo pretty, but withal ſo unconſtantly produced, and ſo eaſily variable by circumſtances, that as it would fill a book particularly to deſcribe them (which for that reaſon I hope to be excuſed for declining) ſo they would much delude him, that ſhould expect to find them every time the ſame, that he had found them once.

And to intimate that by the by, to make ſeveral trials in a ſhort time, and thereby produce variety of figures, it is not an ill expedient to expoſe the liquor one would have congealed, in very ſhallow veſſels; or, if it be put into other veſſels, to leave it, but of very little depth. And if the veſſel it ſelf be highly refrigerated, either by the cold air, or by having ſalt and ice applied to the outſide of it, the congelation may ſucceed much the more nimbly; ſo that within a ſhort while the ſame liquor, being divers times thawed and frozen again, may poſſibly exhibit variety of figures. And the production of ice may be alſo much accelerated, by dipping into the liquor, one would have congealed, the convex ſurface of ſome glaſs or other ſmooth body, that will not imbibe water; for thereby the depth of the liquor will be exceedingly extenuated, and how much ſuch a thinneſs or want of depth, may diſpoſe a liquor to be ſpeedily penetrated and congealed by the cold, may be gueſſed, by what is above delivered in the ſection out of *Olearius*, of the way of multiplying ice in *Perſia*, by making water thinly diffuſe it ſelf over a plate of ice, or ſome other aptly figured, and very cold body: in confirmation whereof, I will add on this occaſion, that I have ſeen a pair of ſtairs, on which, though they were ſituated near to three chimneys, commonly furniſhed with fire, almoſt all the day long, the water, that was employed to waſh them, being thinly ſpread with a mop, would preſently congeal (though they aſſured me it was hot, when it was begun to be laid on) and cover the ſtairs with gloſſy films of ice. And I have likewiſe obſerved in a very ſharp night, that the water, which dropped down from the noſe of a pump, was ſo well congealed, as it was ſliding away, that the ice thus arreſted in its paſſage (in which it will eaſily be granted that it ſpreads it ſelf very thinly) had raiſed a kind of icy pyramid of a conſiderable bigneſs and height.

I Forgot to mention in due places (and therefore think fit to take notice of it here) that when I was conſidering of the ways, whereby it might be manifeſted to thoſe, that want nice ſcales, or diſtruſt their ſkill to uſe them, whence that ice comes, that appears on the outſide of frozen eggs put to thaw in cold water, I found it ſomewhat difficult to pitch upon

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upon ſuch a liquor as I deſired. For if common water be the liquor employed, it may be ſaid, that it affords the matter, whereof the ice in queſtion is made: and if I employed liquors, that were ſpirituous or ſaline, it might be pretended, that the froſt (as they ſpeak) did indeed come out of the frozen egg, though the ſhell did not appear caſed with ice, becauſe as faſt as the froſt came to the outſide of the egg, it was reſolved by the ſpirituous or ſaline corpuſcles of the liquor: wherefore as an expedient, I reſolved to make uſe of oil of turpentine, as a liquor, which I had found uncongealable by the greateſt cold I had obſerved in our climate, and which yet (as may appear by the third paragraph of the XVIth title) was more indiſpoſed, than common water itſelf, to thaw any icy efflorescence, that might be emitted by the egg. But the experiment was tried, without uniformity in the ſucceſſes. For the firſt time I put a frozen egg into oil of turpentine, I did not obſerve, that any ice was produced on the outſide: neither was the event differing, when another time I put two frozen eggs together into a ſmall veſſel full of that oil, though to refrigerate the liquor, the veſſel was for a while placed upon a mixture of ſalt and ice, though alſo the egg-ſhells at their gaping cracks (produced by congelation) diſcovered, that the contained liquor was well frozen. I intended to proſecute the experiment another time (wanting ice to do it then) becauſe that once, when during the trial I was hindered from watching it, one of my domeſticks, whom I ordered to look after it, aſſured me, that the egg, that was put to thaw in the oil of turpentine, had there obtained ice on the outſide of it; which I ſhould readily have believed, upon the ſcore of a like obſervation, I had made my ſelf, in two eggs that were frozen to the bottom of the veſſel, wherein they had been put to thaw, were it not, that one or both of them had been, by a miſtake, dipt in water, before they were put into the above mentioned oil.

SOME readers may have expected to find, among the examples recited of the influence of cold upon the air, that ſtrange ſtory, which is related by the learned *Joſephus Acoſta*, of the mountains of *Pariacaca*, (which he ſeveral times traverſed: *) but beſides that I have delivered a great part of it already in another treatiſe, I was loth to ſay more, till I had leiſure (which I have not now) to diſcuſs the ſcruples, that I have not ſo much about the matter of fact, as about the cauſe, which perhaps may be ſomething beſides cold. But ſince I have mentioned this XVIIIth ſection, I will here take notice of what I then intended, but forgot to ſet down; namely, that to the inſtances alledged to ſhew the coldneſs of regions not to be always proportionate to their greater and leſs vicinity to the pole, we may add a memorable one afforded us by a country ſo well known to many of us, as *New England*; where, though the winters are ſo long and bitter, as we have formerly related out of Mr. *Wood*'s proſpect of that country, (which has been confirmed to me by an American phyſician, that lived there;) yet that region, which is ſo very much colder than ours, is in many places no leſs than ten or eleven degrees remoter from the pole.

I SHALL add to the ſame XVIIIth ſection, that as to the experiment I there mentioned concerning winds, and which I aſſociate with the teſtimony of the newly named Mr. *Wood*; I find, that the ſeaſon of the year, and ſome other circumſtances, may vary it more than one would eaſily have ſuſpected. For though I faithfully recited the phænomena, as I then (and that ſometimes with witneſs) took notice of them, yet ſome months after, and in other weather, having occaſion to repeat the former part of that experiment, I was ſomewhat ſurprized at the ſucceſs. For coming to blow upon the ball of a ſealed weather glaſs, which though in its kind very tender, might be probably preſumed to be leſs ſo, than a thermoſcope made with a pendulous drop of water (ſuch as that, mentioned in the forecited paragraph) I found, that if I continued to blow any thing long and briſkly, the highly rectified ſpirit of wine (which circumſtance I therefore name, becauſe poſſibly the nature of that may ſomewhat alter the caſe) would ſometimes manifeſtly enough ſubſide. And in that paragraph of the 18th title, where I recited the experiment of the infrigidating winds, I ſhould more expreſly have taken notice of this circumſtance, that to ſatisfy my ſelf, that it was not the bare wind, as ſuch, whoſe operation upon the air included in the ball of a weather-glaſs, made the liquor to aſcend, we put a mark upon the height it ſtood at, when we had a pretty while blown upon it; and then, without removing the bellows, put ice and ſalt about the iron pipe of it. By which mixture the air, that was afterwards blown through that pipe, was ſo cooled in its paſſage, as to make the liquor very manifeſtly to aſcend, even in a weather-glaſs, where I did employ (as I have elſewhere declared, that I often do) quickſilver inſtead of water, or ſpirit of wine. And leſt the vicinity of the frigorifick mixture ſhould be ſuſpected to have cauſed this contraction of the included air, we did ſometimes purpoſely intermit the moving of the bellows, without removing the weather-glaſs; and though, notwithſtanding that vicinity, the liquor would begin a little to ſubſide; yet when ever the cold ſpirits, or the corpuſcles of the highly refrigerated air, were, by the playing of the bellows anew, approached to, or rather brought to touch in ſwarms the globular part of the inſtrument, the mercury would manifeſtly aſcend. And ſince we are ſpeaking of weather-glaſſes, I ſhall on this occaſion ſubjoin, that certain circumſtances may alſo vary the ſucceſs of another experiment (ſomewhat of kin to that lately repeated, about the pendulous drop) which is briefly mentioned not far from the beginning of the firſt preliminary diſcourſe. For though the common thermometers, that are here wont to be ſold in ſhops, have uſually the pipe of the bolt-head very large in

* Where a wonderfully piercing, though not ſenſibly violent cold, does ſometimes ſuddenly kill men, and yet preſerve their bodies untainted whole years together.

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in proportion to the ball, and therefore are in that place ſaid to be weather-glaſſes not nice; and though on ſuch inſtruments in certain temperatures of the air (intimated by the word *ſometimes*, employed in that paſſage) the air blown out of a pair of bellows againſt ſome part of the included air, would not, eſpecially at the beginning, make the air ſenſibly contract itſelf, and the liquor aſcend; though at the very firſt and ſecond blaſt, the coldneſs of this artificial wind might be very ſenſible to the touch (which was the thing intended to be taught in that paſſage) yet having the curioſity with other bellows, at another ſeaſon of the year, to blow long upon the ball of a not common, but nice weather-glaſs of my own making, furniſhed with a pipe, that was very ſlender, I divers times (but not always) found the tincted liquor manifeſtly enough to aſcend, as if the wind, conſiſting of a more compreſſed air, did, by containing a greater number of cold particles in the ſame room, more affect the internal air, than the contact of the calm and lax outward air did before; which diſparity of events has given me the deſign of making further trials with differing thermoſcopes, at other ſeaſons of the year, to ſee if I can bring the matter to ſome certainty, by diſcovering the cauſe of this contingency, in which I afterwards ſuſpected, that ſome light degree of warmth or coolneſs in the bellows themſelves, which, as being unmanifeſt to the ſenſe, ſcaped unheeded, might have an intereſt. When I was about ſome of the former experiments, I would willingly have had an opportunity of trying, with a good ſealed weather-glaſs, what difference there would be, betwixt the cold of the nocturnal air in a froſty night, in places, where the air was kept calm, by being ſheltered from the wind, not by inhabited buildings, but by ſome wall, or other body, whence any warm effluviums were leaſt to be expected; and betwixt the cold of the ſame air, in places, where cold winds, eſpecially northerly or eaſterly, did freely and ſtrongly blow. But my occaſions then confining me to a town, I had not conveniency to make any ſecure obſervations of that nature; and even in a more commodious place, unleſs it were determined, whether there be corpuſcles properly and conſtantly frigorifick, upon whoſe account ſome winds are ſo much colder than others, there may ariſe more ſcruples about this matter, than I muſt now ſtay to diſcuſs.

THERE is one thing more, that, it may be, is not impertinent to mention, before I take leave of the XVIIIth title: for in confirmation of what is there delivered, concerning the viciſſitudes of theſe troubleſome degrees of cold and heat, within the compaſs of the ſame natural day, complained of by the patriarch *Jacob*, and by *Olearius*, I ſhall add, that having ſince had opportunity to inquire about ſuch matters of a learned phyſician, lately come from the *Indies*, he aſſured me, that notwithſtanding the violent heats of the day, he uſually obſerved the nights to be ſo very cold, that he was poſitive ſome frigorifick ſteams did, in the night, aſcend out of the earth, and make it very expedient, if not neceſſary, for thoſe Engliſh, that live in the warmer parts of *America*, to imitate the natives, in keeping fires under their hammocks, or hanging-beds.

I THOUGHT it might be a luciferous experiment, in relation to an hypotheſis, that might be propoſed about cold, to try, whether, if two ſuch liquors were provided, as by being mixed together, would ſo far forth loſe their fluidity, as to obtain at leaſt the conſiſtency of an unguent, this impediment, put to the former confuſed and greater agitation of their parts, would produce any ſenſible degree of cold; this I thought fit to try, by immerſing, for a competent time, the ball of a tender ſealed weather-glaſs into each of the liquors apart, and then into the ſoft mixture, their coalition would compoſe. To produce ſuch a mixture more ways than one, it was not difficult for me, by the help of ſome experiments, I had provided to add to my *Hiſtory of Fluidity and Firmneſs*. But though a ſtrong ſolution of minium (or calcined lead) in ſpirit of vinegar, or a very ſtrong infuſion of good quick-lime in water, will either of them (and one of them I did make uſe of, though I have forgotten which) coagulate a juſt proportion of good ſallad-oil (to name no other made by expreſſion) into ſuch a conſiſtence as I have been ſpeaking of; yet for want of a ſealed thermoſcope, tender enough, I cannot now repeat the experiment, and till I do, I dare not draw any experiment from it; though, if I much miſremember not, when I ſhewed it an ingenious perſon, neither he nor I could perceive, that the liquors, by being deprived of their fluidity, had acquired any thing of coldneſs diſcoverable by the ſealed weather-glaſs.

IT is much controverted among the curious, whether water be capable of compreſſion; and divers have of late inclined to the negative, upon obſerving a want of cogency in the experiments, that have been brought to evince the affirmative. What trials and obſervations we long ſince made about this matter, may be met with in ſome of our other treatiſes, wherefore I ſhall now ſubjoin, that having imagined, that cold might afford a hopefuller way, than (for aught I know) any man has uſed, of bringing this controverſy to the deciſion of an experiment, I made that attempt, that is mentioned in the XIIth title; in proſecution of which, as ſoon as I could procure ſome, though but ſome of the accommodations, which I long wanted, I made an experiment, which I ſhall ſubjoin, becauſe though it be not ſo conſiderable, as with better implements I could have made it, yet the way I choſe, has (as I partly intimated elſewhere) theſe two advantages; that the force employed to compreſs the air, is both very great, and very gradually, and ſlowly applied; and that the veſſel will not, like thoſe, that have been hitherto made uſe of, give any paſſage through its pores to water, though violently compreſſed.

WE took then a round ball of glaſs, furniſhed with a moderately long pipe, and having filled it with water, till the liquor reached

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within ſome inches of the top, it was hermetically ſealed up, and then the water, by a mixture of beaten ice and ſalt, was made to freeze from the bottom upwards; and that without breaking the glaſs, the unfrozen water, by the expanſive endeavour of that which was freezing, might be impelled upwards, and ſo at once both compreſs the air, and be preſſed upon by it, having by this means condenſed the air, as far as we thought ſafe to do in a glaſs, that was not ſtrong, we cropt off the ſmall apex of the glaſs, and immediately the compreſſed air flew out with a great noiſe, and that part of the pipe which was unfilled with water, was filled with ſmoke, that made it look white, and great ſtore of little bubbles haſtily aſcended from the lower parts of the water, to the upper (where moſt of them quickly broke) in ſuch a way, as put me in mind of what uſually happens upon the opening of veſſels that contained bottled beer. But that, which was principally to be noted, was this, that beſids the bubbles or froth, the water itſelf (at leaſt ſuppoſing, that no little unheeded bubbles, that did not quite emerge, could ſenſibly contribute to its height) immediately aſcended in the pipe about $\frac{3}{4}$ of an inch, which (having carefully marked the firſt and ſecond ſtations, with a diamond on the outſide of the glaſs) it was eaſy for us to meaſure.

I HAVE elſewhere propoſed a ſuſpicion, that in the attempts, that had been till then made, to compreſs water, the condenſation (in caſe there were really any) might perchance proceed from the compreſſion of the aerial particles, that I have ſhewn to be wont to lie diſperſed in the pores of common water. But though the conſiderable expanſion of water, notwithſtanding the breaking of the bubbles in our preſent experiment, ſeems manifeſtly to argue, that this could be but a concurrent cauſe (if it had any ſenſible effect at all) of our phænomena, yet I dare not abſolutely rely, even upon an experiment, that ſeems ſo cogent, till I have ſatisfied myſelf, that no ſpringineſs, which I have ſometimes ſuſpected might be in the ice, had any intereſt in the produced effect; and that the great preſſure of the forcibly condenſed air, did not make the glaſs it ſelf ſtretch or yield. For if it were able to do ſo, then the parts of the violently diſtended glaſs, upon the removal of the forcible preſſure of the air (which muſt ceaſe upon the breaking of the hermetical ſeal) returning to their former ſtraitneſs below, will make the water aſcend ſomewhat higher in the pipe. But though I could not procure glaſſes, as well very thick, as conveniently ſhaped, wherewith to examine this ſuſpicion, which I likewiſe would have tried by the bulk of the glaſs in water, before and after the letting out of the compreſſed air; yet becauſe moſt readers will probably think ſo much caution more than neceſſary, I ſhall add, that if I had not wanted conveniencies, and had not had miſchances, the experiment would, in likelihood, have been advanced; eſpecially care being taken, that the air left in the pipe ſhould be well refrigerated before its being ſealed up, (as we ſometimes did by ice and ſalt, applied in a perforated box to the outſide) leſt part of its ſpring ſhould depend upon an evanid degree of heat; upon which account the pipe ought beforehand to be drawn ſo ſlender, that the glaſs may be melted together in a trice. For though for want of ſtrong glaſſes, and the beſt ſort of inſtruments to ſeal up ſuch with, the ſucceſs was not ſtill ſo conſiderable as I hoped for; yet as four or five other trials, made, as well with another liquor, as with water, did exhibit a manifeſt intumeſcence of the liquors (without computing the froth produced at the top;) ſo in the experiment lately mentioned, if we had judged them ſtrong enough to endure ſuch a compreſſion of the included air, as we have often made on other occaſions, the effect would probably have been much more conſiderable. For though the difference betwixt the length of the ſame water compreſſed and uncompreſſed amounted to an aqueous cylinder of $\frac{3}{8}$ of an inch in height, yet the air, that made this compreſſion of the water, was itſelf reduced but from eight inches to five; ſo that it took up almoſt half its former room, whereas we have ſometimes reduced it to an 18th or 20th part thereof. If I had been accommodated with one of my pneumatical engines, I ſhould have tried, whether water being firſt carefully freed from the latitant air in the exhauſted receiver, and then compreſſed after the manner hitherto recited, the event of the trial would have been conſiderably varied.

I MIGHT add, as other phænomena of our experiment, that when we broke off the ſealed apex of the glaſs, before the included air was much compreſſed, there neither would be any great noiſe made, nor any conſiderable froth produced, at the top of the water; and that having had the curioſity to repeat the experiment in one of the ſame glaſſes, that had been already uſed and with the ſame water, that had been already compreſſed in it, we found, that upon the breaking off the hermetical ſeal the ſecond time, the water did nevertheleſs aſcend into the pipe betwixt $\frac{1}{8}$ and $\frac{1}{4}$ part of an inch. And to theſe particulars I could both add other circumſtances, that I took notice of in the ſame experiment, and ſubjoin many other experiments and obſervations, but that I am already tired. And though I have not found cold to be a ſubject over-fruitful in experiments pleaſing and curious, yet now I am grown ſomewhat acquainted with it, I find it may ſuggeſt ſo many other new ones, that ſince the barrenneſs of my theme will not eaſily put a period to this treatiſe, it is fit that now at length I ſhould let my wearineſs and want of leiſure do it.

AN

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AN EXAMEN of ANTIPERISTASIS, AS It is wont to be TAUGHT and PROVED.

THEMISTIUS, CARNEADES, ELEUTHERIUS.

THEMISTIUS.

1. AS for *Antiperiſtaſis*, the truth of it is a thing ſo conſpicuous, and ſo generally acknowledged, that I cannot imagine what ſhould make ſome men deny it, except it be, that they find all others to confeſs it. For though in other caſes they are wont to pretend experience for their quitting the received opinions, yet here they quit experience it ſelf for ſingularity, and chuſe rather to depart from the teſtimony of their ſenſes, than not to depart from the generality of men.

2. AND to evince, that this is not ſaid *gratis*, I might obſerve to you, that there are no leſs than three grand inducements, that have led both the vulgar and philoſophers (two ſorts of men, that ſeldom agree in other things) to conſent in the acknowledgement of *Antiperiſtaſis*; authority, reaſon, and experience. But though I think fit to name them all three, yet ſince the firſt of them, by having, as I juſt now noted, invited our adverſaries to diſſent from the truth, is a ſomewhat unlikely medium to prevail on them to acknowledge it, I ſhall inſiſt only on the two latter; having once declared, that I lay aſide the firſt, not as worthleſs in it ſelf, but needleſs to my cauſe.

3. TO begin then with the arguments afforded us by reaſon.

WHAT can there be more agreeable to the wiſdom and goodneſs of nature, who deſigning the preſervation of things, is wont to be careful of fitting them with requiſites for that preſervation; than to furniſh cold and heat with that ſelf-invigorating power, which each of them may put forth, when it is environed with its contrary. For the order of the univerſe requiring, that cold and heat ſhould reſide in thoſe bodies, that often happen to be mingled with one another, thoſe two noble and neceſſary qualities would be too often deſtroyed in the particular ſubjects, that harboured them, if provident nature had not ſo ordered the matter, that when a body, wherein either of them reſides, happens to be ſurrounded by other bodies, wherein the contrary quality is predominant, the beſieged quality, by retiring to the innermoſt parts of that, which it poſſeſſes, and thereby recollecting its forces, and as it were animating it ſelf to a vigorous defence, is intended or increaſed in its degree; and ſo becomes able to reſiſt an adverſary, that would otherwiſe eaſily deſtroy it.

4. TO illuſtrate as well as ſupply this argument drawn from reaſon, we ſhall need but to ſubjoin the other afforded us by experience, which does almoſt every day give us not only opportunity to obſerve, but cauſe to admire the effects of this ſelf-invigorating power, which, when occaſionally exerted, we call Antiperiſtaſis: and theſe phænomena ought the more to be acquieſced in, becauſe they may ſafely be looked upon as genuine declarations, which nature makes of her own accord, and not as confeſſions extorted from her by artificial and compulſory experiments, when being tortured by inſtruments and engines, as upon ſo many racks, ſhe is forced to ſeem to confeſs whatever the tormentors pleaſe.

5. TO proceed then to the ſpontaneous phænomena of nature I was recommending, we ſee, that whereas in ſummer the loweſt and higheſt regions of the air are made almoſt unſufferable to us by their heat, the cold expelled from the earth and water by the ſun's ſcorching beams retires to the middle region of the air, and there defends it ſelf againſt the heat of the other two; though in the one, that quality be aſſiſted by the almoſt perpendicular reflection of the ſun-beams, and in the other it be rendered very conſiderable by the vaſtneſs of the upper region of the air, and its vicinity to the element of fire.

AND as the cold maintains itſelf in the middle region, by virtue of the intenſeneſs, which it acquires upon the account of Antiperiſtaſis; ſo the lightning, that flaſhes out of the clouds, is but a fire produced in that middle region, by the hot exhalations penned up, and intended in point of heat by the ambient cold, to a degree, that amounts to aſcenſion.

6. BUT though theſe be unqueſtionably the effects of that exceſſive coldneſs; yet we need not go ſo far as the tops of mountains to fetch proofs of our doctrine, ſince we may find them at the bottom of our wells. For though *Carneades* perhaps will not, yet the earth as well as the air doth readily acknowledge the power of Antiperiſtaſis. And if the reaſon above alledged did not evince it, our very ſenſes would. For as in ſummer, when the air about us is ſultry hot, we find, to our great refreſhment, that the air in cellars and vaults, to which the cold then retreats, is eminent for the oppoſite quality; ſo in winter, when the outward air freezes the very lakes and rivers, where their ſurfaces are expoſed to it, the internal air in vaults and cellars in winter, which becomes the ſanctuary of heat, as in ſummer it was of cold, is able not only to keep our bodies from freezing, but to put them into ſweats. And not only wells and ſprings, upon the account of their reſting in, or coming out of the deepeſt parts of the earth, continue fluid, whilſt all the waters, that are contiguous to the air, are by

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by the exceſſive cold hardened into ice; but the water freſhly drawn from ſuch wells feels warm, or at leaſt tepid to a man's hand put into it. And as if nature deſigned men ſhould not be able to contradict the doctrine of Antiperiſtaſis, without contradicting more than one of their own ſenſes, ſhe has taken care, that oftentimes the water, that is freſhly drawn out of the deeper ſorts of wells and ſprings, ſhould manifeſtly, as I have ſeen it, ſmoke, as if it had been but lately taken off the fire. And this may be ſaid, without a metaphor, to demonſtrate *ad oculum* the reality of Antiperiſtaſis; there being no other cauſe, to which this warmth can be attributed, than the retiring of the heat from the cold external air to the lower parts of the earth and water; ſince both theſe elements themſelves being naturally cold, and one of them in the ſupreme degree, the heat we are mentioning, is ſo far from being likely to be generated in ſo unfit a place, that, if it were not very great, it muſt be extinguiſhed there, by the coldneſs of the ſuperiour air, and that of the inferiour parts of the earth.

ELEUTHERIUS. 7. That *Carneades* may have but one trouble, to anſwer the allegations to be made in favour of Antiperiſtaſis, I hope he will give me leave, (according to my cuſtom of ſiding with either party, as occaſion invites me) to add to the familiar obſervations mentioned by *Themiſtius* ſome others, that are leſs obvious. For I frankly confeſs to you, that when I conſider, what intereſt the unheeded diſpoſitions of our own bodies may have in the eſtimates we make of the degrees of cold and heat, in other bodies; I ſhould not lay much weight upon the phænomena, that are wont to be urged as proofs of Antiperiſtaſis, if ſome inſtances, ſomewhat leſs liable to ſuſpicion, did not countenance the doctrine they are urged for. I know, that *Carneades* being wont ſo to propoſe his opinion about Antiperiſtaſis, as only to deny, that it is clearly made out by the reaſons or experiments, that are commonly produced to evince it, it were ſomewhat improper to urge him with obſervations, that are not familiar, and wont to be imployed; but I know too, that he is not ſo rigid an adverſary, as not to allow me to mention ſome uncommon relations, that I learned from men of good credit. I ſhall tell you then, that having purpoſely inquired of ingenious men, that had been very deep under ground, ſome in coal-pits, and ſome in mines; one of them affirmed, that, at the bottom of the grove (as they call it) or pit, he found it very hot in *September*. And another, that he often found it hot enough, to be troubleſome in winter. And a third, (who is himſelf a great ſeeker for mines, and a maſter of conſiderable ones) that he found it to be hot all the year long. And to manifeſt, that ſuch obſervations will hold even in gelid regions, I ſhall repeat to you, what I remember I read in the voyage of that ingenious navigator, Captain *James*; who, giving an account of *Charleton Iſland*, which, by his relation, ſeems to be as cold as *Iceland* itſelf, ſays, (pag. 36.) *That his men found it more mortifying cold, to wade through the water in the beginning of* June, *when the ſea was full of ice, than in* December, *when it was increaſing*. And he adds, that which makes more to our preſent purpoſe, and proves the other part of the doctrine of Antiperiſtaſis; *That, from their well, out of which they had water in* December, *they had none in* July. And, to ſtrengthen the obſervation yet further, I will acquaint you with a relation to this purpoſe, not unworthy your notice: for, hearing of an ingenious phyſician, that lived ſome years in and about *Moſcow*, I applied myſelf to him, (as poſſibly you may have done; for, if I miſtake not, I have ſeen you together) to know, whether, in that frozen region, he obſerved the cellars to be hot in winter. And his anſwer to that, and ſome other queſtions of the like nature I put to him, amounted in ſhort to this; that when I inquired, whether their ſprings and wells were not all frozen in the winter, he told me, that he ſaw ſome ſprings, whoſe waters froze not at all near the ſpring-heads, but, at a good diſtance from thence, it began to be thinly caſed over with ice. He added, that his own well was about ſix fathoms deep, between the ſurface of the earth, and that of the water, and that the water in it was, as I remember, about three or four fathoms deep; and that not only this well froze not all the winter, but that the well of his neighbour, which was but one fathom deep to the ſuperficies of the water, did not freeze neither. And, to ſatisfy my curioſity about the ſteams of this water, he told me, that when a bucket of water was newly drawn, if it were agitated, it would ſmoak; but that, from the well itſelf, when the water in it was left quiet and unſtirred, he did not perceive any ſmoak to ariſe.

8. To all this, I ſhall add this further circumſtance, that, having purpoſely inquired, whether, in the winter, he found it as hot in cellars at *Moſcow*, as it is wont to be, in that ſeaſon, in our's? he anſwered me, that when the doors and windows were carefully ſhut, to hinder the immediate commerce betwixt the included and external air, he often found, if he ſtayed long in his cellar, it would not only defend him from the ſharpneſs of the Ruſſian cold, as bitter as that is wont to be in winter, but keep him warm enough, to be ready to ſweat, though he laid by his furs. So that, if we may rely, either upon the teſtimony of our ſenſes, we muſt neceſſarily admit cellars to be warmer in winter, than in ſummer, and conſequently allow an Antiperiſtaſis.

CARNEADES. 9. Though I were not in haſte, I ſhould not think it neceſſary to reply any thing elſe to the firſt part of what was ſaid by *Themiſtius*, than that, what he alledges of the univerſality of the opinion he maintains, may ſerve to recommend that, which he oppoſes. For the vulgar doctrine about Antiperiſtaſis being, as he urges, received and taught in all the ſchools, the innovators, he declaims againſt, muſt have learned it there, among the other Peripatetick tenents, that youth is wont

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to be imbued with in thoſe places; ſo that it may rather ſeem the love of truth, than of ſingularity, that engages them againſt an opinion, which before was their own, as well as that of the generality of ſcholars; and conſequently, againſt which they cannot maintain a paradox, that does not imply a retractation. But I ſhall not proſecute my anſwer to *Themiſtius*'s preamble, ſince *Eleutherius*, whom I am chiefly to ſpeak to, is too much a philoſopher, to think truth leſs herſelf, for being ſlenderly attended; or to think any men the leſs like to be her followers, becauſe they are but few. To come then directly to the controverſy itſelf, I think, I need not tell one of you, that the other miſtakes my opinion about it. For I perceive, *Eleutherius* hath not quite forgotten, that I have not been wont to deny an Antiperiſtaſis, as it may be, but only as it was wont to be, explicated. But ſince *Themiſtius* ſeems to be willing to have me his antagoniſt in this controverſy, and ſince *Eleutherius* himſelf ſeems to conſpire with him, I am content to act, for a while, the part, you gentlemen would have me take upon me, and will propoſe to you part of what I would ſay for the opinion you impute to me, in caſe I were really of it.

10. To come then to the controverſy itſelf, though *Themiſtius* has drawn his proofs for the Antiperiſtaſis of the ſchools, partly from reaſon, and partly from experience; yet the very ſame two topicks ſeem to me to afford conſiderations, that may juſtly warrant our calling it in queſtion.

11. And firſt, if we look upon the reaſon of the thing, conſidered abſtractedly from the experiments, that are pretended to evince an Antiperiſtaſis, we cannot but think, it may be very rational, I ſay not, to doubt of it, but to reject it. For, in the firſt place, according to the courſe of nature, one contrary ought to deſtroy, not to corroborate, the other. And next, it is a maxim among the Peripateticks themſelves, that natural cauſes always act as much as they can. And certainly, in our caſe, wherein we treat not of living creatures, I cannot but think the axiom phyſically demonſtrative. For inanimate agents act not by choice, but by a neceſſary impulſe; and, not being endowed with underſtanding and will, cannot of themſelves be able to moderate or to ſuſpend their actions. And as for what *Themiſtius* alledges, that it was neceſſary for the preſervation of cold and heat, that they ſhould be endowed with ſuch a power of intending themſelves, I muſt freely confeſs, that though, in living creatures, and eſpecially in the bodies of the perfecter ſorts of animals, I do, in divers caſes, allow arguments drawn from final cauſes; yet where only inanimate bodies are concerned, I do not eaſily ſuffer myſelf to be prevailed upon, by ſuch arguments. Nor is there any danger, that cold and heat, whoſe cauſes are ſo radicated in nature, ſhould be loſt out of the world, in caſe each parcel of matter, that happens to be ſurrounded with bodies, wherein a contrary quality is predominant, were not endowed with an incomprehenſible faculty of ſelf-invigoration. And nature either does not need the help of this imaginary power, or oftentimes has recourſe unto it to very little purpoſe: ſince we ſee, that theſe qualities ſubſiſt in the world, and yet, *de facto*, the bottles of water, wine, and other liquors, that are carried up and down in the ſummer, are regularly warmed by the ambient air. And in *Muſcovy*, and other cold northern countries, men, and other animals, have oftentimes their vital heat deſtroyed by the cold, that ſurrounds them, being thereby actually frozen to death. And I ſomewhat wonder, that the followers of *Ariſtotle* ſhould not take notice of that famous experiment, which he himſelf delivers, where he teaches, that hot water will ſooner congeal than cold. For, if the matter of fact were true, it would ſufficiently manifeſt, that the heat harboured in the water is deſtroyed, not invigorated, by the coldneſs of the air, that ſurrounds it; ſo that *Themiſtius* muſt, I fear, on this occaſion, take ſanctuary in my obſervation; and, to keep *Ariſtotle* from deſtroying his own opinion, with his own experiment, had beſt ſay, as I do, that it is not true. And though it is not to be denied, that white ſurrounded with black, or black with white, becomes thereby the more conſpicuous; yet it is acknowledged, that there is no real increaſe, or intenſion, of either quality, but only a comparative one, in reference to our ſenſes, obtained by this collation. Nor does a pumice-ſtone grow more dry than it was in the fire or earth, by being tranſferred into the air or water, and conſequently environed with either of thoſe two fluids, which *Themiſtius* and his ſchools teach us to be moiſt elements; neither will you expect to find a piece of dim glaſs become really more tranſparent, though one ſhould ſet it in a frame of ebony, though that wood be ſo opacous as to be black. And whereas it is commonly alledged, as a proof of the power, nature has given bodies, of flying their contraries, that drops of water falling upon a table will gather themſelves into little globes, to avoid the contrary quality in the table, and keep themſelves from being ſwallowed up by the dry wood; the cauſe pretended has no intereſt in the effect, but little drops of water, where the gravity is not great enough to ſurmount the action of the ambient fluid, if they meet with ſmall duſt upon a table, they do, as they roll along, gather it up, and their ſurfaces being covered with it, do not immediately touch the board, which elſe they would ſtick to. And to ſhew you, that the globular figure, which the drops of water, and other liquors, ſometimes acquire, proceeds not from their flying of dryneſs, but either from their being every way preſſed, at leaſt almoſt equally, (for in ſome caſes alſo they are not exactly round) by ſome ambient fluid of a diſagreeing nature, or from ſome other cauſe, differing from that the ſchools would give; I ſhall deſire you to take notice, that the drops of water, that ſwim in oil, ſo as to be ſurrounded with it, will likewiſe be globular; and yet oil is a true and moiſtening liquor, as well as water. And the drops of quickſilver, though upon a table they are more diſpoſed, than water, to gather themſelves into

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into a round figure; yet that they do it not as humid bodies, is evident, becauſe quickſilver, broken into drops, will have moſt of them globular, not only in oil, but in water. And to ſhew you, that it is from the incongruity it has to certain bodies, that its drops will not ſtick upon a table, nor upon ſome other bodies, but gather themſelves into little ſpheres, as if they deſigned to touch the wooden plain but in a point; to manifeſt this, I ſay, we need but take notice, that though the ſame drops will retain the ſame figure on ſtone or iron, yet they will readily adhere to gold, and loſe their globulouſneſs upon it, though gold be a far drier body than wood, which, as far as diſtillation can manifeſt, muſt have in it a ſtore of humid parts of ſeveral kinds, (I mean both watery and unctuous.) But this may reliſh of a digreſſion; my taſk being only to examine the Antiperiſtaſis of cold and heat, concerning which, I think, I had very juſt cauſe to pronounce the vulgar conceit very unconſonant to the nature of inanimate beings. For the Peripateticks talk of cold and heat ſurrounded by the oppoſite quality, as if both of them had an underſtanding, and foreſight, that, in caſe it did not gather up its ſpirits, and ſtoutly play its part againſt the oppoſite, that diſtreſſes it, it muſt infallibly periſh; and as if, being conſcious to its ſelf of having a power of ſelf-invigoration, at the preſence of its adverſary, it were able to encourage itſelf, like the hero in the poet, that ſaid,

See the History of Fluidity, Sect. 19.

Nunc animis opus eſt, Æneæ, nunc pectore firmo.

Which indeed is to transform phyſical agents into moral ones.

ELEUTH. 12. The validity of the Peripatetick argument, drawn from reaſon, conſidered abſtractedly from experience, I ſhall leave *Themiſtius* to diſpute out with you, at more leiſure. And ſince you well know, that the only arguments I alledge to countenance Antiperiſtaſis, were built upon experience, as judging them either the beſt, or the only good ones, I long to hear what you will ſay to the examples, that have been produced of that, which you deny.

CARNEADES. 13. That, *Eleutherius*, which I have to anſwer to the examples, that are urged, either by the ſchools, or by you, in favour of Antiperiſtaſis, conſiſts of two parts. For, firſt, I might ſhew, that, as reaſon declares openly againſt the common opinion, ſo there are experiments, which favour mine, and which may be oppoſed to thoſe you have alledged for the contrary doctrine. And, ſecondly, I might repreſent, that of thoſe examples, ſome are falſe, others doubtful; and thoſe, that are neither of theſe two, are inſufficient, or capable of being otherwiſe explicated, without the help of your hypotheſis. But, for brevity's ſake, I ſhall not manage theſe two replies apart, but mention, as occaſion ſhall ſerve, the experiments, that favour my opinion, among my other anſwers to what you have been pleaſed to urge on the behalf of *Ariſtotle*.

14. To begin then with that grand experiment, which, I remember, a late champion for Antiperiſtaſis makes his leading argument to eſtabliſh it, and which is ſo generally urged on that occaſion; I mean, the heating of quick lime in cold water: I confeſs, I cannot but admire the lazineſs and credulity of mankind, which have ſo long, and generally, acquieſced in what they might ſo eaſily have found to be falſe. This I ſay, becauſe I was poſſibly the firſt, that has had both the curioſity and boldneſs to examine ſo general and conſtant a tradition; yet I doubt not, that you will ſoon be brought to take it, as well as I, for as great, as popular, an error. For, to let you manifeſtly ſee, how little the incaleſcence of the quick lime needs be allowed to proceed from the coldneſs of the ambient water, if, inſtead of cold water, you quench it with hot water, the ebullition of the liquor will not only be as great, as if the water were cold, but oftentimes far greater. As I have ſometimes, for curioſity, removed boiling water from the fire; and when the liquor had left off boiling, but was yet ſcalding hot, I put it into a convenient quantity of quick-lime; and, after a while, the water, which, as I ſaid, had ceaſed from boiling, began to boil afreſh, with ſo much vehemence, and ſuch large and copious bubbles, that it threatened to run over the pot, of which, before the effervеſcence, a conſiderable part was left unfilled. And this was no more, than what I might well look for, hot water being much fitter than cold, to pervade nimbly the body of the lime, and haſtily diſſolve, and ſet at liberty the igneous and ſaline parts, wherewith it abounds. And how much a greater intereſt ſalts may have in ſuch incaleſcencies, than cold, I have alſo taken pleaſure to try, by pouring acid ſpirits, and particularly ſpirit of ſalt, upon good quick lime. For, by this means, there would be a far greater degree of heat excited, than if I had, inſtead of ſpirit of ſalt, uſed common water; and this, whether I imployed the ſpirit cold or hot. For in either caſe, ſo ſmall a portion, as about the bigneſs of a walnut of lime, put into a ſmall glaſs, would, by the addition of a little ſpirit of ſalt, put to it by degrees, both hiſs and ſmoak, and boil very ſurprizingly; and, notwithſtanding the ſmall quantity of the matter, would conceive ſo great a heat, that I was not able to hold the glaſs in my hand. And to ſhew ſome friends, how little heat excited in quick lime by cold water proceeds barely from the coldneſs of that liquor, I cauſed a parcel of good lime to be beaten ſmall, and putting one part of it into a glaſs veſſel, I drenched it plentifully with oil of turpentine, more than it would imbibe, and the other portion of the lime I likewiſe drenched with common water: both theſe liquors having ſtood in the ſame room, that they might be reduced by the ſame ambient air, to a like degree of coldneſs, the event of this trial was (what I looked for) that the oil of turpentine, notwithſtanding its actual coldneſs, and the great ſubtilty and piercingneſs of parts, which it has in common

common with other chymical oils, being of an incongruous texture, ſeemed not to make any diſſolution of the powdered lime, and did not, for ſeveral hours, that I kept it, produce, that I perceived, any ſenſible heat in the lime. Whereas, to ſhew, that it was not the fault of the lime, that part of it, on which common water had been poured, did, after a little while, conceive ſo ſtrong a heat, that it broke a large open-mouthed glaſs, into whoſe bottom it was put; and not only grew ſo hot, that I could not endure to hold it in my hand, but ſent out at the mouth of the glaſs, though that were conſiderably diſtant from the lime, a copious white fume, ſo hot, that I could not well ſuffer the holding of my hand over it. And, to prevent a poſſible, though invalid, objection, which I foreſaw might be drawn againſt the experiment made with oil of turpentine, from the oleaginous nature of that liquor, I covered a piece of the ſame ſort of quick-lime, I have been ſpeaking of, with highly rectified ſpirit of wine: but though I left them together all night, yet I perceived not, that the liquor had at all ſlacked the lime, which continued in an entire lump, till, upon the ſubſtituting of common water, it did, as I remember, quickly appear to be ſlacked, ſince it fell aſunder into a kind of minute white powder, which was (bating the colour) almoſt like mud, and would eaſily, by a little ſhaking, be diſperſt, like it, through the water.

ELEUTHERIUS. 15. I ingenuouſly confeſs to you, *Carneades*, that what you ſay ſurprizes me; for I thought it ſuperfluous to try my ſelf ſo acknowledged an experiment, being not able to imagine, that ſo many learned men, for ſo many ages, ſhould ſo unanimouſly, and confidently, deliver a matter of fact, of which, if it were not true, the falſity could be ſo eaſily diſcovered,

CARNEADES. 16. For my part, *Eleutherius*, I confeſs, I am wont to doubt of what they teach, that ſeldom or never doubt. And I hope you will forgive me, if, having found an aſſertion ſo general and uncontrouled, of a falſity ſo eaſy to be diſproved, I be inclinable to ſuſpect the truth of their other inferiour traditions about Antiperiſtaſis; and of theſe I will mention the two chiefeſt I have met with among the moderns, (for being contrived experiments, I preſume you will eaſily believe, they came not from *Ariſtotle*, nor the ancient ſchoolmen, that commented upon him.)

17. THE firſt of theſe is the freezing a pot to a joint-ſtool, by a mixture of ſnow and ſalt, by the fire's ſide; in which caſe it is pretended, that the fire does ſo intend the cold, as to enable it to congeal the water, that ſtagnated upon the ſurface of the ſtool, betwixt that and the bottom of the pot. But how little need there is of Antiperiſtaſis in this experiment, you may gueſs by this, that I have purpoſely made it with good ſucceſs in a place, in which there neither was, nor ever probably had been, a fire, the room being deſtitute of a chimney. And this trial of mine I could confirm by divers other experiments of the like nature, but that this one is ſufficient.

18. I PROCEED therefore to the other experiment, which is delivered by very learned men, and for whom I have a great reſpect: according to theſe, if you take a ſomewhat large pot, and having filled it almoſt with ſnow, place in the middle of the ſnow a phial full of water; this pot being put over the fire, the coldneſs of the ſnow will be ſo intended by the heat, from which it flies into the water, that it will turn that liquor into ice. But though I ſeveral times tried this experiment, yet neither in earthen, nor in ſilver veſſels, could I ever produce the promiſed ice. And I remember, that an eminently learned man, that wondered to find me ſo diffident of what he ſaid, he knew to be true, readily undertook to convince me, by an ocular proof; but with no better ſucceſs, than I had had before. So that the argument may be plauſibly enough retorted upon them, that urge it.

19. AND in caſe the trial ſhould ſucceed ſome time or other, (for that it doth not ordinarily, I have ſhewn already) yet will there be no neceſſity of deriving the effects from Antiperiſtaſis. For though, in ſuch caſes, the fire would contribute to the production of the effect, by haſtening the diſſolution of the ſnow; yet the heat of the fire does but remotely, and by accident, cauſe the production of ice, ſince other agents will do the ſame thing, that are qualified to make a quick diſſolution of the ſnow, whether they be hot or no; as I have tried, that ſpirit and crude ſalt of nitre will either of them, by a due application, bring ſnow, by diſſolving it, to congeal water, though the ſpirit and the nitre be generally agreed upon to be actually cold, and one, if not both of them, to be potentially cold too.

20. HAVING thus diſpatched the experiments, pretended to evince an Antiperiſtaſis, I muſt now examine the obſervations, that are alledged to that purpoſe, of which the principal, if not the only, are theſe; the coldneſs of the middle region of the air; the increaſe of mens ſtomachs in winter; the generation of hail; and the heat and cold in cellars, and other ſubterraneal places, when the contrary quality reigns in the air.

21. TO begin with the firſt of theſe: I will not now diſpute, whether the ſecond region of the air have really that coldneſs, that is wont to be aſcribed to it; though our friend Mr. *Boyle* ſeems to doubt, whether that region's being always and every where cold, hath been as ſtrongly proved, as aſſerted. But paſſing over that queſtion, I ſee no need of imploring the help of Antiperiſtaſis, to keep the ſecond region of the air for the moſt part cool. For without at all taking in the cauſe imagined by the ſchools, an obvious and ſufficient one may be eaſily aſſigned. For the air being, as to ſenſe, cold of its own nature, ſo that when we feel it hot, it is made ſo by ſome adventitious agent; and that agent being for the moſt part the ſun, who heats the air chiefly, though not only, by its reflected beams; their heat is ſo languid, by that time they arrive, diſperſed, at the ſecond region of the air, that they are not able to overpower

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its natural coldneſs, increaſed perchance by ſome frigorifick ſpirits, that may find a more commodious harbour there, than in other parts of the atmoſphere. And whatever be the true cauſe of the coldneſs in the middle region of the air, I cannot but admire to find that coldneſs ſo confidently aſcribed to Antiperiſtaſis, by *Themiſtius* and his friends the Ariſtotelians: for, according to them, it is the nature of the element of air to be as well hot as moiſt, and according to the ſame Peripateticks, both the upper region of the air always, and the lower in ſummer is hot; the former by the neighbourhood of the imaginary element of fire, and the latter by the reflexion of the ſun-beams from the earth: which two poſitions being laid together, I would fain learn of any Ariſtotelian, how Antiperiſtaſis comes to take place here? For, according to them, thoſe bodies have their cold and heat increaſed by Antiperiſtaſis, that are on both hands aſſailed by bodies of a contrary quality, to that which is natural to the ſurrounded body: whereas the whole element of air, and conſequently the middle region, being, as they would perſuade us, hot, of its own nature; what ſhadow of probability is there, that the higheſt and loweſt regions, by being hot, ſhould make the middle region, which is alſo naturally hot, intenſely and durably cold? But though the objection is ſo clear, that it needs not to be inſiſted on; yet, becauſe it is but an argument *ad hominem*, I ſhall add this, for their ſakes, that are not in this point Peripateticks: that it does not appear to me, that if the air be naturally rather cold than hot, the ſecond region muſt owe the intenſeneſs of that quality to an Antiperiſtaſis. For the ground of the opinion, I oppoſe, being this, that both the firſt and the third regions are conſiderably hot; I would gladly find it proved as to the upper region. I confeſs, I have not found the aſſertion contradicted, but that as little convinces me, as the uncontrouledneſs of the tradition about quick-lime, that I lately confuted. It is true, there are two reaſons alledged, to evince the heat of the ſupreme region of the air, but neither of them to me ſeems cogent. For the firſt is, that the vicinity of this region to the element of fire makes it partake a high degree of heat. But if we conſider the diſtance of that element, which they place contiguous to the orb of the moon, and how little nearer to it the concave part of the upper region is, than the convex of the middle, we may eaſily conceive, that in two diſtances, that are both of them ſo immenſe, ſo ſmall a diſparity cannot be much (if at all) more conſiderable, than the greater nearneſs of one ſide of a ſheet of paper, held at three yards diſtance from an ordinary fire, in compariſon of the diſtance of the other ſide of the ſame paper; or than the diſtances of a ſmall wart, and of the neighbouring parts of the face, when a man comes within two or three yards of the fire. But it is not worth while to proſecute this conſideration, becauſe the argument againſt which it is alledged, is built upon the groundleſs ſuppoſition of the element of fire, a figment, which many of themſelves do daily grow aſhamed of, as indeed its exiſtence is as little to be diſcovered by reaſon, as perceived by ſenſe.

22. THE other argument for the heat of the third region of the air is, that fiery meteors are kindled by it. But not now to queſtion, whether all meteors, that ſhine, and therefore paſs for fiery, are really kindled exhalations; we ſee, that in the lower region of the air, and in winter, thoſe fires, which are called either *Helena*, or *Caſtor* and *Pollux*, are generated in great ſtorms, and hang about the ſails and ſhrouds of ſhips. Nay, do we not much more frequently ſee, that lightning is produced at all ſeaſons of the year? for in warmer countries thouſands have obſerved it to thunder (and ſo have I in winter) in the middle region of the air. And ſince it is not the heat of the inferiour part of the air, that kindles thoſe exhalations; and if notwithſtanding the coldneſs of the ſecond region, fiery meteors may be frequently generated there; I ſee no reaſon, why the production of ſuch meteors ſhould argue the heat of the third region of the air. And if that region be not hot, then it will, I preſume, be eaſily granted, that the coldneſs of the ſecond muſt very improperly be attributed to ſuch an Antiperiſtaſis, as it is generally aſcribed to.

23. I COME next to conſider that aphoriſtical ſaying of *Hippocrates*, *Ventres hyeme eſſe calidiores*, together with the obſervation, whereon it ſeems to have been grounded. I will not now examine, whether any arguments for the contrary may be drawn from the heat and thirſt men feel in ſummer, and the refreſhment they then find by drinks and fruits, and other aliments that are actually cold. For that, which I principally intended to ſay, is this, that I much more doubt the matter of fact delivered in the aphoriſm, than that, in caſe it be true, it may be made out without the help of Antiperiſtaſis, in the vulgar and ſcholaſtic notion of that term.

24. I CONSIDER then firſt, that the proof, that iswont to be brought of the greater heat of men's ſtomachs in winter, is, that men are wont to have then a greater appetite to their meat. But though I pay ſo much reſpect to the great *Hippocrates*, as to allow the aphoriſm in a ſenſe; yet I admit it to be true but upon an hypotheſis, that I do not admit to be ſo. For the aphoriſm ſuppoſes, that the digeſtion of meat in the ſtomach is made by heat; and conſequently, that the ſtronger digeſtion, that is wont to be made in winter, is an argument of the ſtomach's being then hotter, than at other ſeaſons of the year. But the erroneouſneſs of this ſuppoſition, I think, I need not ſolemnly prove to *Eleutherius*, who, I doubt not, has taken notice of ſeveral things in nature, that agree not with it, and particularly of the ſtrong concoction, that is made in the ſtomachs of divers raveneous fiſhes, whoſe ſtomachs and blood are yet, as I have purpoſely obſerved, ſenſibly cold: but if it ſhould in ſome caſes prove true, that there is really in men's bodies a far greater heat in winter than in ſummer, yet this would not infer an Antiperiſtaſis in the

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ſenſe, wherein I oppoſe it. For the vital heat lodged in the heart, always generating out of the blood and juices, that continually circulate through that part, great ſtore of ſpirits and warm exhalations, which are wont to tranſpire through the pores of the ſkin in much greater quantities, than, notwithſtanding the affirmations of *Sanctorius*, any thing but my own trials could have perſuaded me; theſe warm ſteams finding the pores of the ſkin ſtraitened and ſhut up, grow more and more copious in the body, and thereby heat the ſtomach, as well as the other internal parts of it: and perhaps alſo the ſame frigorifick corpuſcles or temperature of the air, that produce cold in winter, may, by ſhutting in certain kinds of effluvia, or perhaps altering the motion or texture of the blood, reduce it to ſuch a diſpoſition, as that the appetite ſhall be increaſed, as well as the concoction in the ſtomach promoted by the ſtomachical menſtruum, or ferment, which either is newly generated in winter, or more copiouſly ſupplied (by the circulating of the blood to the ſtomach) in that ſeaſon than in others. And to ſhew, that a good appetite may be procured by agents endowed with very diſtinct and contrary qualities; do not we ſee, that ſpicy ſauces, wine and vinegar, do all of them, in moſt men, beget an appetite, though the two former be confeſſedly hot, and the latter cold? And ſo wormwood and juice of lemons have both of them frequently relieved dull and weak ſtomachs, though the one be confeſſedly a hot ſimple, and the other a cold. And in ſome caſes, either the frigorifick corpuſcles themſelves, and perhaps ſome other unknown to us, that they may bring along with them, may ſo ſollicit the ſtomach, as to breed an eager appetite, not preciſely by their being cold or hot, but by their peculiar nature; as we have inſtances of ſome, that in theſe parts by walking on the ſnow, procure to themſelves a bulimia. And the learned *Fromundus* relating, how he himſelf, by walking along on the ſnow, was ſurprized with ſuch a Βουλιμία, takes notice, that the chief cauſe of the fainting was in the ſtomach; and that he found by his own experience, that that part was diſcompoſed, convelled, and provoked to caſt. To which he adds, (what makes much for my preſent purpoſe) that he thinks now the chief cauſe of the bulimia to conſiſt in certain ſteams, that do peculiarly affect the ſtomach, which they gnaw and diſtend. And juſt before he obſerves, that ſtraining to fetch deep coughs is a preſent remedy in this diſtemper, by diſcharging the ſtomach and lungs of thoſe ſnowy ſpirits, which were either attracted in reſpiration, or had ſome other way inſinuated themſelves in thoſe parts: ſo that beſides the cold abſtractedly conſidered, the ſtomach may be peculiarly affected by other, either attributes or concomitants, of the frigorifick corpuſcles, that grow powerful in froſty weather; with which it well agrees, that divers have been obſerved to be ſubject to bulimia's in theſe parts of the world, though in our warmer climates ſuch men endure nothing near ſo great a cold, nor are ſo much inconvenienced by it, as multitudes of others, that in *Nova Zembla*, and other gelid regions, never complained of having contracted, even in the midſt of winter, any ſuch diſeaſe.

25. ANOTHER argument, that is ſpecious enough, urged in favour of Antiperiſtaſis, is borrowed from the production of hail, which is preſumed to be generated in ſummer only, not in winter; and, according to *Ariſtotle*, and the ſchools, is made in the loweſt region of the air, by the cold of the falling drops of rain ſo highly intended by the warmth it meets with in the air near the earth, as to congeal the water, wherein it is harboured. But though I freely confeſs to you, that I think the generation of hail difficult enough to be ſolidly explicated; yet I ſcruple not to reject the received doctrine about it, for ſeveral reaſons, of which I will now name four.

26. FOR in the firſt place, it is not univerſally true, as is ſuppoſed, and the Ariſtotelian doctrine requires, that hail falls not but in ſummer, or very hot weather. For I have myſelf obſerved it within this twelvemonth, to hail at the latter end of *November*, and that, when ſome froſty days have preceded, and when the coldneſs of the weather was complained of. Nay, the longeſt ſhower of hail, that either I, or ſome others, remember ourſelves to have ever known, I obſerved to fall about a week before the end of *January*, on a night preceded by a very froſty day, which itſelf was preceded by a ſharp fit of froſty weather. And here I muſt not pretermit this circumſtance, that when the tedious ſhower was over, there came to the houſe, where I then was, a maid, that is ſervant to one of my domeſticks, and related to her maſter, and others, how ſhe was for a good while miſled out of the beaten way, where the ſtorm found her, by an *Ignis fatuus*, which ſhe followed, till by its paſſing over a place, where ſhe found an unpaſſable hedge, it both ſhewed her, that ſhe was out of her way, and that it was no candle, though ſhe had ſo confidently thought it one, that ſhe called out to the party, ſhe preſumed it to be carried by. I will leave *Themiſtius* to unriddle, how the nocturnal air could kindle a fiery meteor by its coldneſs, and at the ſame time congeal the falling drops of water into ice by its warmth; and ſhall only add, that I doubt not but other obſervations of the like kind have been often made, though perhaps ſeldom recorded. For within the compaſs of a very few weeks of the ſtorm, ſome ſervants of mine affirmed themſelves to have obſerved it to hail two or three times, beſides that already mentioned.

27. NEXT, if *Ariſtotle* have rightly aſſigned the cauſe of hail, it is ſomewhat ſtrange it ſhould not fall far more frequently in ſummer, and eſpecially in hot climates, than it does, conſidering how often in all probability the drops of rain fall cold out of the ſecond region into the warm air of the firſt. And more ſtrange it is, that even in thoſe parts of *Egypt*, where it rains frequently enough and plentifully (for ſo *Proſper Alpinus*, that lived long there, aſſures us it does) though not about *Grand Cairo*,

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Cairo, yet about *Alexandria* and *Peluſium*, it ſhould never hail no more than ſnow, as the ſame learned phyſician (a witneſs above exception) affirms. Beſides, whereas it is pretended, that ſnow is generated in the upper region of the air, and hail always in the lower; my own obſervation has afforded me many inſtances, that ſeem to contradict the tradition. For I have obſerved in I know not how many great grains of hail, that, beſides a hard tranſparent icy ſhell, there was as it were a ſnowy pith of a ſoft and white ſubſtance, and this ſnowy part was moſt commonly in the middle of the icy, which made me call it pith, but ſometimes otherwiſe. And laſtly, whereas the favourers of Antiperiſtaſis would have the drops of rain, in their deſcent, to be congealed apart in the ambient air; not to urge, how little the irregular and angular figures, we often meet with in hail, do countenance this doctrine; hail often falls in grains, too great by odds to be fit to comply with *Ariſtotle*'s conceit. For not to mention the grains of hail I have obſerved my ſelf to be of a bigneſs unſuitable to this opinion, divers learned eye-witneſſes have informed me of their having obſerved much greater than thoſe I have done: and particularly an eminent Virtuoſo of unqueſtionable credit affirmed both to me and to an aſſembly of Virtuoſi, that he had ſome years ago, at *Lyons* in *France*, obſerved a ſhower of hail, many of whoſe grains were as big as ordinary tennis-balls, and which did the windows and tiles a miſchief anſwerable to that unuſual bulk. And *Bartholinus* affirms, that he himſelf obſerved, in another ſhower of hail, grains of a more unwonted ſize; a ſingle grain weighing no leſs than a whole pound. But though this it ſelf is little in compariſon of what I remember I have ſomewhere met with in learned authors, yet it may abundantly ſuffice to diſprove the vulgar conceit about the generation of hail, till we meet in theſe countries with ſhowers of rain, whoſe ſingle drops prove to be of ſuch a bigneſs; which I preſume thoſe, that aſcribe hail to Antiperiſtaſis, will not eaſily ſhew us.

28. I COME now to conſider the laſt, and indeed the chiefeſt example, that is given of Antiperiſtaſis; namely, the coldneſs of cellars, and other ſubterraneal vaults in ſummer, and their heat in winter. And as the argument, wont to be drawn from hence, conſiſts of two parts, I will examine each of them by it ſelf.

29. AND firſt, as to the refreſhing coldneſs, that ſubterraneal places are wont to afford us in ſummer, I both deny, that they are then colder than in winter; and I ſay, that though they were, that coldneſs would not neceſſarily infer an Antiperiſtaſis.

30. WE muſt conſider then, that in ſummer our bodies having for many days, if not ſome weeks, or perhaps months, been conſtantly environed with an air, which, at that ſeaſon of the year, is much hotter, than it is wont to be in winter, or in other ſeaſons, our ſenſes may eaſily impoſe upon us, and we may be much miſtaken, by concluding upon their teſtimony, that the ſubterraneal air we then find ſo cool, is really colder than it was in winter, or at the ſpring; as they that come out of hot baths think the air of the adjoining rooms very freſh and cool, which they found to be very warm, when coming out of the open air, they went through thoſe warm rooms to the bath, and the deepneſs and retiredneſs of theſe ſubterraneal caves keep the air, they harboured, from being any thing near ſo much affected with the changes of the ſeaſon, as the outward air that is freely expoſed to the ſun's warming beams, which pierces with any ſenſible force ſo little away into the ground, that diggers are not wont to obſerve the earth to be dried and diſcoloured by them beyond the depth of a very few feet. And I have found, that in very ſhallow mines not exceeding ſix or ſeven yards in depth, though the mouth were wide, and the deſcent perpendicular enough, the air was cool in the heat of ſummer; ſo that the free air and our bodies, that are always immerſed in it, being much warmer in ſummer than at other times, and the ſubterraneal air, by reaſon of its remoteneſs from thoſe cauſes of alteration, continuing ſtill the ſame, or but very little changed, it is no wonder, there ſhould appear a difference as to ſenſe, when our bodies paſs from one of them to another.

31. AND ſuppoſing, but not yielding, that the air of cellars and vaults were really colder in ſummer than in winter, that is, were diſcovered to have a greater coldneſs, not only as to our ſenſe of feeling, but as to weather-glaſſes; yet why ſhould we for all that have recourſe, for the ſolution of the difficulty, to an Antiperiſtaſis, which it is much harder to underſtand, than to find out the cauſe of the phænomenon, which ſeems in ſhort to be this; that whereas (which I ſhall ſoon have occaſion to manifeſt) there are warm exhalations, that in all ſeaſons are plentifully ſent up by the ſubterraneal heat, from the lower to the ſuperficial parts of the earth, theſe ſteams, that in winter are in great part repreſſed, or checked in their aſcent, by the cold froſt or ſnow, that conſtipates the ſurface of the earth, and choaks up its pores; theſe exhalations, I ſay, that being detained in the ground would temper the native coldneſs of the earth and water, and conſequently that of ſprings, and of the ſubterraneal air, are by the heat, that reigns in the outward air, called out at the many pores and chinks, which that heat opens on the ſurface of the ground, by which means the water of deep ſprings and wells, and the ſubterraneal air, being deprived of that, which is wont to allay their native or wonted coldneſs, are left to diſcloſe a higher degree of it, and ſeem to have that quality increaſed, when indeed it is but freed from the mixture of its contrary, that weakened it.

32. As for the heat, we find in cellars and vaults in winter, the ſolutions already given will be applicable to that phænomenon alſo, which by this way is yet more eaſy to be accounted for than the other. For having firſt queſtioned the matter of fact, it will not be difficult to ſhew, that, though it were true, it need not be aſcribed to Antiperiſtaſis.

33. I THINK then, that it may be juſtly queſtioned, whether cellars in general are hotter in winter than they are in ſummer. For as for

for the teſtimony of our ſenſes, upon which alone men are wont to conclude the affirmative, it may in this caſe eaſily and much delude us. For thoſe places being ſheltered from the winds, and kept from a free communication with the outward air, are much leſs expoſed than others to the action of thoſe agents, whatever they be, that produce cold in the air. So that our bodies being conſtantly immerſed in the air refrigerated by the winter, and conſequently brought nearer to the temper of that air, when we bring thoſe bodies into cellars, the ſubterraneal air muſt ſeem warm to us, though in it ſelf it were unvaried as to its temper.

34. Now that many cellars are indeed colder in the midſt of winter, than in the heat of ſummer, though not in reſpect of our ſenſes, yet in reſpect of other bodies, that have not the ſame prediſpoſitions, I am induced to believe by ſome experiments of mine own, purpoſely made. And firſt in a froſty evening having hung out in a garden two ſealed weather-glaſſes, that they might be reduced as near as could be to the temper of the ambient air, I brought one of them into a cellar, and it ſoon began manifeſtly to riſe, and in two or three hours aſcended five or ſix diviſions, whilſt the water in another ſealed weather-glaſs, that continued ſuſpended in the ſame part of the garden, did rather a little ſubſide, than at all riſe, which is agreeable to the firſt part of what I was ſaying; namely, that the air, harboured in cellars, is not ſo powerfully affected by the ordinary efficients of cold, as the free and external air. And now as to the ſecond part of what I was ſaying, that the ſubterraneal air, though it be leſs affected by the outward cold, may be ſomewhat affected by it, inſtead of growing hotter by Antiperiſtaſis; I ſhall add, that early in the morning in froſty weather the liquor in the ſame weather-glaſs appeared more ſubſided, than over night, which ſhews, that the external air did leſſen, not increaſe the warmth of the air in the cellar. And having there placed a wide-mouthed glaſs of oil, which in thawing weather remained all night fluid as before, the ſame liquor, the very next night, which was a bitter froſt, was ſo far frozen and congealed, as to ſink in other oil, and keep its ſurface exactly, though the glaſs were inclined and turned upſide down. And proſecuting my trial, I found, that in a ſharp froſt, and great ſnow, the liquor, that on the Thurſday night was beneath the fourth knub or mark of diviſion, a ſudden thaw coming with a ſouth wind, the next morning in the ſame cellar the liquor was aſcended to the eighth mark. And continuing the weather-glaſs in the ſame cellar for a good while, to watch its alterations every night and morning, I remember I met with, and regiſtered more obſervations, that confirmed me in my opinion, though it is ſo long ago, that I have forgot the particular circumſtances. And after theſe trials meeting with a learned Polander, I did, without declaring my opinion, inquire of him, whether in his country he had at any time obſerved beer to freeze in cellars in froſty weather; to which he anſwered, that in the coldeſt winters, if the beer were ſmall, the barrels would oftentimes be frozen, but not if it were ſtrong. But I need not have recourſe to foreign teſtimony, having my ſelf obſerved here in *England*, more than one barrel of beer to be frozen in the cellar in exceeding cold weather. Inſomuch that one of the barrels being full, and the liquor expanded by freezing, was forced out at certain chinks, which ſeem to have been made by that expanſive force, and the liquor ſo ejected, adhered in a conſiderable lump to the outſide of the veſſel; and yet this cellar had its windows carefully ſhut, and not only was near a kitchen, where fire was conſtantly kept, but, which was more conſiderable, it had this principal mark of being a good cellar, that in the heat of ſummer it uſed to afford me drink ſufficiently cool. And now to requite *Eleutherius* with the teſtimony of that very perſon, phyſician to the Ruſſian emperor, whoſe authority he lately alledged againſt me, I ſhall confeſs, that as he ſuſpects I had conference with this doctor, and when I diligently enquired of him, whether their cellars at *Muſcow* were really very cold in ſummer, he anſwered me, that they were not, and that they had diſtinct cellars for ſummer and for winter; that their ſmall beer would quickly grow ſour in their cellars in ſummer, if their veſſels were not kept in ſnow; that therefore their way was to make at the bottom of their ſummer cellars (to which belonged a well, to receive the water dropping from the melted ſnow) a deep layer of ſnow, on which they afterwards caſt a convenient quantity of water, that the whole maſs might be turned into a kind of ice. In this ſnow they keep their caſks, making ſometimes a layer of ſnow, and a layer of caſk, and digging out their veſſels, as they had occaſion to uſe them. By all which it may appear, how groundleſly it is univerſally affirmed of cellars, that as they ſeem to the ſenſe, ſo they really are hotter in winter than in ſummer.

35. BUT if it ſhould happen, (as in ſome places it is not impoſſible, but that it may) that ſome vaults and cellars are really warmer in ſummer than in winter; yet I ſee not, why this ſhould reduce us to the acknowledgement of an Antiperiſtaſis; for neither could the effect be made out by that, nor would there be any neceſſity to have recourſe to it.

36. AND firſt I might content my ſelf to repeat, what I have formerly ſaid, to ſhew the incongruity of Antiperiſtaſis in general to nature's ways of acting. And I might add, that to imagine with ſome late Peripateticks, (whom all their reverence to *Ariſtotle* has not ſo far blinded, as not to let them ſee the unreaſonableneſs of his conceit) that in winter the warmth of the ambient air retreats into cellars and vaults to ſhun its contrary, is to make meer accidents, or at beſt inanimate agents, act with knowledge and deſign. But I will rather repreſent, that, though Antiperiſtaſis were intelligible, it were improper to alledge it in our caſe. For to invigorate the warmth of the air by the cold, the air muſt, according to them, be environed with other cold bodies, and the heat muſt retire it ſelf as far as it can from them. And accordingly it is obſerved, that

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in winter the deepeſt cellars are warmeſt; but in the caſe before us the ſubterraneal air, though above, it have the cold that reigns in winter; yet beneath, the ſubterraneal heat makes the earth very warm. This I ſhall not wonder, if you look upon, as new and paradoxical; and therefore I ſhall apply myſelf to the proof of it, and to convince you, I ſhall not imploy the obſervations of chymiſts and mineraliſts, for fear you ſhould ſuſpect them of ignorance or deſign; but I will uſe only the authority of a learned phyſician, who, I think, was alſo a profeſſor of mathematicks, who, in but too many points, is a ſtout Peripatetick, and who, above all this, profeſſes himſelf to be an eye-witneſs of what he relates. This author then informs us, that about the year 1615, he had a curioſity to viſit the mines of *Hungary*, and particularly to go down into the deep golden mine at *Cremnitz*; and that after he had deſcended fourſcore or a hundred fathoms, he found it exceſſively hot, though he had but a ſlight linen garment on; and though he be a maintainer of Antiperiſtaſis, yet he affirms, that not only the overſeer and workmen of that mine, but alſo thoſe of divers other mines, unanimouſly aſſured him, that that lower region of the earth was all the year long very hot, and as well in winter, as he found it in ſummer. So that it ſeems, in winter the heat of the ſubterraneous parts leſs remote from the ſuperficies, cannot be intended by the coldneſs of the more internal parts of the earth, thoſe parts being themſelves not always cold, but always hot.

EUTHERIUS. 37. But you may, *Carneades*, remember, that this very author tells you *, that he found the ſupreme region of the earth, as he calls it, which is that next the air, exceedingly cold, both as he went down into the mine, and as he came up again, and that he aſcribes that coldneſs to Antiperiſtaſis.

CARNEADES. 38. Right, but you may remember too, that he relates †, that it was in *July*, and in very hot weather, that he went down into the mine, and that, to avoid fouling his clothes, he put them off, and exchanged them for a light looſe linen garment, ſuch as the diggers wore; and this himſelf mentions, as that which much increaſed the coldneſs he felt. So that if, beſides this, we conſider, that he deſcended into a cooler place, with a body already affected with the great heat which he elſewhere takes notice, that that ſeaſon had given the outward air, and perhaps much heated by riding or walking to the mine, we ſhall not wonder, that he found the change very ſenſible as he went down. And we ſhall leſs wonder, that he found the upper region of the earth, as he calls it, more cold, when he came up again; ſince, beſides the toil of going to and fro, and aſcending through narrow, low, and difficult paſſages, he came out of a place exceſſively hot; inſomuch that he tells us, that the overſeer of the mine would not go back with him the ſame way he came, but took a far ſhorter, though it were a more dangerous way, cauſing himſelf to be drawn up in a perpendicular grove; and rendering this reaſon, that it was very unhealthy, when one comes out of a place, where the diggers work naked, and where one is even melting into ſweat, to make any long ſtay in the ſuperiour region of the earth. So that beſides that this author, altho' he maintains Antiperiſtaſis, yet he allows this upper region to be hot in winter, as well as cold in ſummer; and conſequently, that in winter it has not a cold region beneath, as well as above it: which is enough to vindicate the thing, for which I firſt alledged his teſtimony. Beſides this, I ſay, to me, who, though I willingly thank him for his narrative, am much more ſwayed by what he relates, than by what he thinks; the matter of fact ſeems very favourable to my opinion: for you ſee, that I can juſtly refer the cold he felt near the ſurface of the earth, to the deception of his ſenſe, but the heat he felt within the bowels of the earth cannot be referred to the ſame cauſe; ſince he tells us, that at the top of that great and perpendicular grove, by which the mine-maſter was drawn up, there aſcended a plentiful ſmoke, that was, even above the mouth of it, felt actually hot: and, beſides his own confeſſion, that the deep parts of the mine were more than ſeemingly hot, I can draw further proofs from theſe two circumſtances, that I have elſewhere met with, in his narrative; the one, that on the ſurface of the earth, it was then exceſſively hot; another, that the ‖ ſmoke, which, notwithſtanding this heat, appeared hot, had in its aſcent paſſed through four or five hundred foot of a cold region of the earth, whereby it may well be ſuppoſed, to have been much infrigidated. To theſe relations of the learned *Morinus*, I will add, that the archbiſhop of *Upſal* affirms **, that in the year 1528, being in *Poland*, he went to viſit thoſe deep mountains, (as he terms them) whence they dig ſolid ſalt, and having deſcended fifty ladders, found, in the deeper places, that the workmen were naked, becauſe of the heat. So that ſuppoſing the time of the year not to be conſiderable in this caſe, it ſeems by this relation, that, provided a man deſcends low enough into the bowels of the earth, he will find it very hot, even in places that want thoſe metals, or marchaſites, or other like mineral ſubſtances, by the action of ſaline liquors, or exhalations, upon which you, *Eleutherius*, have, I remember, ſometimes ſuſpected, that the heat obſerved in mines may be produced.

39. I HAVE hitherto ſhewn, that the heat of cellars and vaults in winter has been very improperly, and now I come to ſhew, that it has

*——*Cæpimus in hanc fodinam per gradus valde ſtrictos profundè admodum deſcendere, per regionem tertè frigidiſſimam, quam ſolis veſtibus metallicis opertus, multo frigidiorem ſenſi*, &c. p. m. 130.

†——*In quam deſcendi menſe Julio, quo anni tempeſtas vigebat calidiſſima, ſicciſſimaque.* p. m. 130.

‖ *Exhalatio aëre levior per ipſum puteum aſcendit magno impetu, in ejus ſummitate adhuc ſenſibiliter calida ipſa æſtate, licet ſupremam terræ regionem tunc frigidiſſimam permeat.* Pag. 128. See alſo page 125.

** *In Polonia vero montes profundiſſimi ſalis ſunt, præſertim in Vieliſca & Bochna, ubi videndi cauſâ tranſcenſis ſcalis, vidi in profundioribus locis laboratores nudos ob calorem, ferreis inſtrumentis eruere opulentiſſimum theſaurum ſalis, veluti aurum & argentum ex mineris inexhauſtis.* Olaus Mag. lib. 13. p. 382.

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has been as unneceſſarily aſcribed to Antiperiſtaſis. For as the air of thoſe places is protected from the greateſt part of the adventitious coldneſs, that reigns in the outward air, ſo the ſubterraneal air has a poſitive cauſe of heat in winter, that it has not in ſummer. For, as I formerly took notice, in ſummer the pores of the earth, being dilated and opened by heat, the warm exhalations, that were wont to be mingled with moiſt vapours in the bowels of the earth, are called out, and exhaled away. For as in the winter, the ſurface of the earth being hardened by froſt, or the pores of it choaked up, or at leaſt much obſtructed, the hot ſteams, that, as I lately proved by our French author's teſtimony (to which I could add that of eminent chymiſts and mineraliſts) do continually, and copiouſly enough aſcend from the warm region, or lower parts of the earth, are in great part detained and impriſoned in cellars, and other ſubterraneal cavities, where conſequently they produce ſuch a heat, as to thoſe, that come out of the cold air, may be very ſenſible. And the rather, becauſe whilſt men, by the coldneſs of the ſeaſon, are more than ordinarily careful, to ſtop up the paſſages, at which the external air may get in, they do, though deſignleſly, ſtop up the vents, at which the ſubterraneous exhalations might get out. And to ſhew you, that this laſt circumſtance is not impertinently taken notice of, I ſhall tell you, that a very grave author having occaſion to mention cellars, relates it, as a practice in divers houſes of a town, where he had been, to keep vents in their deep cellars, which in the ſummer were from time to time opened, partly to keep the places ſweet and wholeſome, and partly to let out the warm exhalations, that would elſe hinder their liquors from keeping ſo freſh, and well. And theſe ſteams were affirmed to have been ſeveral times taken notice of, to aſcend viſibly into the free air like a ſmoke; which ſeveral phænomena, and particularly what I formerly related of the hot fumes, that manifeſtly aſcended out of the great grove in the Hungarian mine, may keep us from thinking incredible.

40. AND now, by what I have hitherto diſcourſed, I have made way for the ſolution of a phænomenon, that is wont to be much urged in favour of Antiperiſtaſis; namely, the ſmoaking of water, that is drawn in froſty weather out of deep wells and ſprings.

41. BUT, firſt, I muſt advertiſe you, that it is improperly enough, that ſome urge for Antiperiſtaſis ſuch examples, as the ſtrange ſpring near the temple of *Jupiter Ammon*, which *Lucretius* and others have obſerved to have been exceeding cold in the day-time, and as hot at night: for, not now to examine, whether this ſtory be not fabulous, or might not be aſcribed to ſome crafty trick of the idolatrous prieſts, that had a mind to impoſe upon *Alexander*, as well as others, and procure an admiration to the place; I conſider, that this, and other the like caſes, ſuch as are the ſprings mentioned in the iſlands of *Maldivia*, by *Pyrard* (a French author, that was ſhipwrecked, and lived long in thoſe parts) muſt be referred to the peculiar nature of the ſprings, or ſome other hidden cauſe: ſince, if the water of them were but ordinary, and the phænomena were the effects of Antiperiſtaſis, it might juſtly be expected, that the like ſhould happen in all ſprings, or at leaſt in very many, which, that it does not, common experience ſhews us. And I would ſay, that this might be the caſe of the ſpring, you mention out of Captain *James*'s voyage, (pag. 63.) but that beſides, that he does not ſay expreſly, that it was frozen in *July*, but only, that then it afforded him no water, which might happen upon divers other accounts: and beſides, that it is manifeſt, that in far hotter countries, where the exceſſive heat of the air might more intend the ſubterraneal cold, if Antiperiſtaſis could do it, there is no talk of any ſuch degree of cold in ſummer, as to freeze the ſprings; beſides this, I ſay, there ſeems to be, through ſome miſtake or other, a contradiction in the relation itſelf, ſince in the ſame voyage, ſpeaking of the ſame month of *December*, he expreſly ſays, that their well was then frozen up; ſo, (pag. 58.) *that dig as deep as they could, they could come by no water*. And he complains, on that occaſion, of the unwholeſomeneſs of melted ſnow-water. It is true, that he ſoon after mentions a ſpring, that he found under a hill's ſide, which did not ſo freeze, (pag. 59.) but that he could break the ice and come to it; but by his very ſending far from his houſe to the ſpring, it appears to have been a conſequence, and therefore a proof, of the uſeleſſneſs of his well in *December*; as his affirmation, that it continued all the year ſo, as to be ſerviceable, when the ice was broken, ſhews, that the Antiperiſtaſis did not freeze it up in ſummer. And having cleared myſelf of ſuch a teſtimony of this ingenious navigator, as would appear very illuſtrious, if there had been no miſtake about it, I ſhall not ſcruple to add, that the late publiſher of the Latin deſcription of *Denmark* and *Norway* informs us, that in or near that little Daniſh iſland *Hueena*, wherein the famous *Tycho* built his *Urani-Burgum*, there is one ſpring among many ordinary ones, that even in the coldeſt winter is never frozen; which, ſubjoins my author, does in theſe regions exceeding rarely happen to be found. *Olaus Magnus* * alſo relates, that in another part of the King of *Denmark*'s dominions, namely near *Nidroſia*, one of the chief cities of *Norway*, there is a lake, that even in that northern region never freezes. And the learned *Joſephus Acoſta* mentions †, that among a very great number of hot ſprings to be met with in *Peru*, *At the baths, which they call the baths of* Ingua, *there is a courſe of water, which comes forth all hot and boiling; and joining unto it there is another, whoſe water is as cold as ice.* He adds, *That the* Ingua (or the Peruvian emperor) *was accuſtomed to temper the one with the other, and that it is a wonderful*

* *Hancque naturam, lacum ſimilem, prope metropolin Nidroſienſem regni Norvegiæ, habere compertum eſt, eo præcipue argumento, quod in mediis frigoribus nunquam congelatur.* Lib. 2.

† *Joſeph. Acoſt. Hiſt. Ind.* pag. 174.

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derful thing to ſee ſprings of ſo contrary qualities, ſo near one to another. Theſe relations, as I was ſaying, I ſcruple not to mention, though at firſt ſight they may ſeem to diſfavour my cauſe. For by theſe and ſome others it may appear, that ſprings may obtain very peculiar and ſtrange qualities, from the nature of the places whence they come, or through which they paſs, or from ſome other cauſes, that are as hidden from us, as the originals of theſe rare waters. And this being once proved, who knows what intereſt ſuch cauſes, as we are ſtrangers to, may have in ſome phænomena, that are wont to be wholly aſcribed to the heat and cold of the ſuperficial part of the ground, and what influence they have upon many other ſprings (beſides thoſe above-mentioned) ſome of which, that are very deep, may riſe from the warm region of the earth, where they may be affected by the place, as both theſe and others may be by mineral juices and ſteams, (ſuch, perhaps, as we know nothing of) though we well know, that ſome of them, that are ſaline, without being at all ſenſibly hot, will powerfully reſiſt congelation.

42. BUT having hinted thus much on this occaſion, I ſhall now proceed to conſider the ſmoking of waters drawn from deep places in froſty weather; and ſhew, that it does not neceſſarily conclude ſuch water to be warmer in winter, ſince that effect may proceed not from the greater warmth of the water in ſuch weather, but from the greater coldneſs of the air. For we may take notice, that a man's breath in ſummer, or in mild winter weather, becomes very viſible, the cold ambient air nimbly condenſing the fuliginous ſteams, which are diſcharged by the lungs, and which in warmer weather are readily diffuſed in imperceptible particles through the air. And I have obſerved, upon the opening of iſſues in ſome men's arms, that though no ſmoke be viſible in ſummer, it will be very conſpicuous in exceeding ſharp weather; though men's arms, at leaſt the external parts of them, ſeem to have leſs heat in froſty weather, than in ſummer; ſince in the former of thoſe ſeaſons, they are wont to be manifeſtly more ſlender, the fleſhy parts and juices being condenſed by the coldneſs of the air. And though the inſenſible tranſpirations, that continually exhale from all the parts of our bodies, are not wont to be viſible here, even in winter; yet in extremely cold countries, as *Nova Zembla*, or *Charleton Iſland*, thoſe effluvia have been obſerved, not only to be thickened, but to be turned into ice itſelf, ſometimes within the ſeamen's ſhoes. And here in *England*, having not long ſince imployed a labouring man to dig a deep hole in very froſty weather, two ſervants of mine, that ſtood by to ſee him work, did both of them aſſure me, when they returned, that the ſteams of his heated body were frozen upon the outſide of his waiſtcoat, which, one of them, whilſt the other was about to give me notice of it, inconſiderately wiped off.

43. AND ſince we ſee, how faſt the water in ponds and ditches waſtes and decreaſes in ſummer, there is no cauſe to doubt, but that it does then continually emit exhalations, as well; if not much more plentifully, than in winter: which may be manifeſtly confirmed by this, that in the ſummer one ſhall often ſee, in the mornings or evenings, the face of the water covered with a miſt or ſmoke, that riſes out of it. And I have ſometimes taken pleaſure to ſee this aggregate of exhalations hover over the water, and make, as it were, another river of a lighter liquor, that conformed itſelf, for a conſiderable way, to the breadth and windings of the ſtream, whence it proceeded. And I think it will be eaſily granted, that the water in ſummer-time is at leaſt as warm at noon, when ſuch exhalations are not viſible, as in the morning when they are, though the air be colder at this part of the day, than at that; which obſervation gives us the true reaſon of the phænomenon.

44. AND though, notwithſtanding all this, it were made to appear, that in ſome caſes, the ſmoking water of ſprings may be really warmer in winter than in ſummer; yet a ſufficient reaſon of the phænomenon may be fetched from what I have already delivered about the detention of the warm ſubterraneal vapours by the froſt, and ſnow, and rain, that make the earth leſs perſpirable in winter.

45. AND becauſe I know *Themiſtius* will look upon a thing ſo diſagreeable to the vulgar opinion, of the coldneſs of the whole element of earth, as a paradox; I will take this opportunity to add a further confirmation to what I have been ſaying.

46. AND firſt, that there ariſe copious and warm ſteams from the lower parts of the earth, may be proved, not only by what I have already mentioned, touching the Hungarian mines, but by the common complaint of diggers in moſt, though not in all deep mines, that they are oftentimes troubled, and ſometimes endangered by ſudden damps, which do frequently ſo ſtuff up and thicken the ſubterraneal air, that they make it not only unfit for reſpiration, but able to extinguiſh the lamps and candles, that the miners uſe, to give them light to work by. And I remember, that I have viſited mines, where having enquired of the diggers, whether thoſe hot exhalations, that compoſe their damps, did not ſometimes actually take fire within the bowels of the earth? I was anſwered, that in ſome of their pits (and particularly in one, that they ſhewed me) though not in all, they did; inſomuch that the exhalation ſuddenly kindling, would make a report at the mouth of the pit like a muſquet, or a ſmall piece of ordnance, and the flame would actually burn off the hair, and ſcorch the ſkins of thoſe workmen, that did not ſeaſonably get out of the pit, when the exhalation appeared to be near in aſcenſion, or did not nimbly fall down flat with their faces to the ground, till the flame was gone out. And one of theſe workmen, that I aſked, affirmed himſelf to have been ſeveral times, to his no ſmall trouble, ſo burned, and that (if I much miſremember not) twice in one day. And it ſeems to me as well as to *Morinus* very probable, that thoſe great quantities of rain and ſnow, and ſtorms,

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and (perhaps) ſome other meteors, that are taken notice of in winter, may rather conſiſt of theſe ſubterraneal ſteams, than the vapours and exhalations attracted by the ſun, (or at leaſt may as much conſiſt of the former, as the latter.) For his heat is then very languid, and acts upon the ground but during the day-time, which is very ſhort, (whereas thoſe meteors are generated indifferently at all hours of the day and night;) and the ſky is oftentimes, for many days together, quite overcaſt with clouds, and the ſurface of the ground ſo conſtipated with froſt, that it will ſometimes freeze even in the ſun-ſhine: ſo that it is not near ſo likely, that the heat of the ſun, in the midſt of all theſe diſadvantages, ſhould be able to elevate ſo great a plenty of exhalations and vapours, as are requiſite to compoſe the rain, and ſnow, and ſtorms, that ſometimes laſt almoſt all the winter, as that they ſhould be ſupplied by ſubterraneal ſteams copiouſly ſent up from the heat, that continually reigns in the lower parts of the earth, and by traverſing the ſea, and at other vents, get up into the air.

47. To make out this, my formerly quoted French author (*P. m.* 136.) relates a very memorable thing, that was told him by the maſters of thoſe mines in *Hungary*, (which are at leaſt as deep as any that I remember I have ſeen or read of;) namely, that the miners were able certainly to foretel ſooner than any other mortals, the tempeſts and ſudden mutations, that were to happen in the air. For when they perceived by the burning blue of their lights, and by other manifeſt ſigns, that they could eaſily take notice of in their grooves, that ſtore of the tempeſtuous damp (if I may ſo call it) was aſcending from the lower parts of the earth, though the ſky above were clear, and the air calm; yet they could aſſuredly foretel the approach of a ſtorm, or ſome other great alteration in the air, which would accordingly enſue within no very long time after. And to confirm this narrative, I ſhall add, not only that it is agreeable to what I lately told you was affirmed to me by other mine-men, but that having enquired of a very ingenious phyſician, who lived many years in *Cornwall*, (a country you know famous for tin-mines, ſome of which are infamous for the damps that infeſt them) he told me, that divers of the experienced fiſhermen aſſured him, that oftentimes they did perceive fiſhes ſhining in the night, ſometimes in one place, ſometimes in another, which was ſuppoſed to be kindled by the ſulphurcous and other ſubterraneous exhalations; and that, when they perceived thoſe fires, (eſpecially if any number appeared in ſeveral places) thoſe, that were well acquainted with the coaſt, would not continue long out at ſea, but rather quit an opportunity of catching fiſh, than not make ſeaſonably to the ſhore; having often obſerved, and particularly this laſt year, that bold and unexperienced mariners, by ſlighting theſe fore-runners of ſtorms, were in few hours ſhipwrecked by them.

48. To this I ſhall add, what happened ſome years ſince, upon the Iriſh coaſt, near a ſtrong fortreſs, called *Duncannon*, where divers of the ſhips royal of *England* lying at anchor, in a place where they apprehended no danger from the wind, there ſeemed ſuddenly to aſcend out of the water, not far from them, a black cloud, in ſhape and bigneſs not much unlike a barrel; which mounting upwards, was not long after followed, as the moſt experienced pilot foretold, with ſo hideous a ſtorm, as forced thoſe ſhips to go to ſea again, and had like to have caſt them away in it. And this account was both written by the principal officers of the ſquadron to their ſuperiours in *England*, and given, ſoon after it happened, by the chief of thoſe eye-witneſſes (and particularly by the pilot) to a very near kinſman of mine (well verſed in maritime affairs) that commanded the land-forces in thoſe parts, as a truth no leſs known than memorable.

49. And on occaſion of what I was ſaying, about the eruption of hot ſteams, in ſeveral parts of the earth, I now call to mind ſomething, that I have met with in a very ſmall, but curious diſſertation, *De admirandis Hungariæ aquis*; whoſe anonymous author I gather, from ſome paſſages in the tract itſelf, to have been a nobleman, governour of *Saros*, and ſome other places in *Hungary*, and to have written this diſcourſe, both for, and to that inquiſitive German Baron, *Sigiſmundus Liber*, famous for the account he gave the world of the embaſſy, whereon he was ſent by the German to the Ruſſian emperor. This anonymous, but noble writer, tells us then, that in that part of *Hungary*, which he calls * *Comitatus Zolienſis*, there is a gaping piece of ground, which does emit ſuch mortal expirations, that they ſuffocate, not only cats and dogs, purpoſely held at the end of long poles over the cleft, but kill even birds, that attempt to fly over it. And in other places of the ſame tract, I have met with many other relations, which if I had time to make a particular mention of, would much countenance what I have been lately ſaying: but though I pretermit ſeveral other inſtances, I cannot but take eſpecial notice of one, which (together with what I lately mentioned to have happened near *Duncannon*) may make it probable, that not only under the ſurface of the dry ground, but in that part of the terreſtrial globe, that is covered with water, there may ariſe ſteams, (and conſequently exhalations) actually, and that conſiderably hot. For in one † place he takes notice, that, not far from the well-known city of *Buda*, there is a hot ſpring (which they call Purgatory) which the waters

* *Qui vero in comitatum Zolienſem, dum aquas perſequimur, ventum eſt, non poſſum præterire hiatum terræ iiſdem in locis famoſum ob peſtilentes expirationes, quibus aves ſupervolantes, & quævis alia animantia extingui conſtat, manifeſto eorum experimento, qui*, &c. Pag. 74.

† *Ibidem eſt ſub dio fons calidarum cæteris amplior, quem Purgatorium vocavere, ea nimirum ratione, quod, quemadmodum proditum eſt in purgatorio pœnas nocentium pro noxarum modo, alias acerbiores, alias mitiores, ita quædam iuſunt aquæ hoc in fonte diſcrimina, nam quâ in eum à Danubii ripâ aditus eſt, ſubfrigida primum, mox tepida, & quo in eum penetraris altius hoc magis calet. In receſſu vero interiore tam eſt calida, ut ferri non poſſit. Eſt etiam is calor haud dubie aquæ hujus proprius; nam alia, quæ dixi, temperamenta veriſimile eſt à Danubio accedere, qui crepidinem hujus fontis lambit, & cum vel modicè excreſcit, totum inundat, neque tamen ita reſtinguit, quin caleat. Quin intra ipſam ripam, qua Danubio perennis curſus eſt calidæ ebulliunt, ubi qui altius mergi volunt lavare conſueverunt.* Pag. 57.

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waters of *Danubius* itſelf are not able to keep from being hot: nay, within the very banks, betwixt which that great river runs, there boil up hot ſprings, where thoſe, that will go deep enough into the water, may commodiouſly bathe themſelves. And * elſewhere ſpeaking of the river *Iſtroganum*, in the ſame county, he adds, that not only the banks of it, but within the very river itſelf, one may diſcover hot ſprings, by removing the ſand at the bottom with one's feet. To this I ſhall add, that having heard of a ditch in the North of *England* (in ſome regards more ſtrange, though leſs famous than the ſulphureous grotta near *Naples*) whence not only ſubterraneal ſteams, but thoſe ſo ſulphureous, as to be eaſily inflammable, did conſtantly and plentifully aſcend into the air, I had the curioſity to make enquiry about it, of the miniſter of the place, (a very learned man, and converſant in mines) who then happened to be my neighbour, and he atteſted the truth of the relation upon his own knowledge. And it was confirmed to me by a very ingenious gentleman, who went purpoſely to viſit this place, and found it true, that a lighted candle, or ſome ſuch actual burning body being held, where this exhalation iſſued out of the earth, would kindle it, and make it actually flame for a good while, and (if I miſremember not) as long as one pleaſed. And as this place was but a few years ſince taken notice of, ſo there may be probably very many others, yet undiſcovered, that may ſupply the air with ſtore of mineral exhalations, proper to generate fiery meteors and winds. I remember, that having lately aſked an inquiſitive gentleman, that is a great ſearcher after mines, whether he did not obſerve ſome meteors near thoſe places, where he is moſt converſant? he told me, that it is very uſual in ſome of them, to ſee certain great fires moving in the air, which in thoſe places, diggers, becauſe of ſome reſemblance (real or imaginary) are wont to call dragons. [And the Ruſſian emperor's phyſician, you were ſpeaking of, informed me a while ſince, that he had, not long ago, obſerved in winter a river in *Muſcovy*, where, though the reſt of the ſurface was frozen, there was a part of it near a mile long, that remained uncovered with ice, which probably was kept from being generated there by thoſe ſubterraneous exhalations, ſince he ſays he ſaw them aſcend up all the way like the ſmoke of an oven.] And in caſe the matter of fact delivered by *Olaus Magnus* † be true, concerning the ſtrange thaws, that ſometimes happen, with terrible noiſes in the great lake *Veter*, thoſe wonderful phænomena may not improbably be aſcribed to the aſcent of great ſtore of hot ſubterraneal ſteams, which ſuddenly cracking thick and ſolid ice in many places at once, produce the hideous noiſes, and the haſty thaw, that he ſpeaks of. And this ſuſpicion may be countenanced partly by this circumſtance, that before theſe ſudden thaws, the lake begins with great noiſe to boil at at the bottom; and partly by what is related by a more authentick writer, I mean that learned traveller the Jeſuit *Martinius*, who witneſſes, that at *Peking*, the royal city of *China*, it is very uſual, that after the rivers and ponds have continued hard frozen over, during the winter, the thaw is made in one day; which, ſince the freezing of the waters (as he tells us) required many, makes it very probable, that the ſudden thaw is effected (as he alſo inclines to think) by ſubterraneal ſteams, which I may well ſuppoſe to be exceeding copious, and to diffuſe themſelves every way to a very great extent, ſince they are able ſo ſoon to thaw the rivers and ponds of a large territory, and that (which makes mainly for my preſent purpoſe) beginning contrary to vulgar thaws, from the bottom upwards.

50. AND having thus manifeſted, that the lower parts of the earth do ſend up great ſtore of exhalations and vapours to the upper parts, it will be obvious to conceive, that as in divers places of the terreſtrial globe, theſe ſteams get into the air, either by the advantage of finding vents, ſuch as thoſe I have already mentioned, or by growing copious enough to force themſelves a paſſage; ſo in moſt other places, where the aſcending ſteams find no commodious vents, or are too faintly driven up to gain themſelves a paſſage, they muſt be repreſſed or detained beneath the ſurface of the earth, which has its pores in winter uſually choaked up with ſnow or rain, or its ſurface conſtipated and hardned with ice or froſt: ſo, that theſe exhalations being pent up, and receiving freſh ſupplies, from time to time, from beneath, it were no wonder, if they ſhould ſomewhat warm deep cellars and wells, where they are thus detained; and therefore our huſbandmen do not ſpeak altogether ſo improperly, when they ſay, that the ſnow keeps the ground warm. And I remember, that Dr. *Smith*, the learned Engliſh Ambaſſador into *Moſcow*, makes it to be one of the principal reaſons of the great fertility, he juſtly aſcribes to the country thereabout, that during almoſt all the winter, the ground is to a great height covered with ſnow; which does not only inrich it by the fertilizing ſalt, which the earth gains from the ſnow, when that comes to be melted, but does alſo contribute to its improvement, by choaking up, or obſtructing the pores, at which the nitro-ſulphureous, and other uſeful corpuſcles, that are ſent up by the ſubterraneal heat, would eaſily get away. And leſt, Gentlemen, you ſhould think, that it is only by the ratiocination, that I conclude, that there is really great ſtore of warm ſteams detained under ground in the winter; I ſhall add this ſenſible obſervation, received from the Ruſſian emperor's phyſician already often mentioned,

* *Neque in ripâ tantum eruuntur Calidæ, ſed etiam intra amnem, ſi fundum ejus pedibus ſuffodias. Calet autem immodicè, nec ſunt idoneæ balneis, niſi temperentur, quod admiſtione frigidæ de proximo hauſtæ in proclivi eſt.* Pag. 65.

† *Nec prætereundum hic puto Lacum eſſe* LX. *milliarum in longitudine, &* XX. *in latitudine Italicorum,* Veter *appellatum in Regno Oſtrogothorum, quæ talis eſt naturæ, quod cum tempeſtuoſo vento congelatus fuerit, & tempus reſolutionis immineat, vehementiſſimo ſtrepitu incipit fundo ebullire & commoveri, magna violentia perrumpere in parvas rimas, vel ſciſſuras, quæ fiunt in glacie, & has in modico temporis ſpatio faciens valdè latas, licet pro tunc glacies in ſpiſſitudine laboverit, pluſquam unum, vel duo brachia.* Lib. primo, pag. 23.

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mentioned, by whom I have been assured, that about *Muscow*, where the surface of the ground is far more constipated in winter, than it is in these parts, and where they are wont to keep their cellars much closer, the subterraneous exhalations being hindered to fly abroad, will in time multiply so fast, that he assures me, that upon the unwary opening of the doors of cellars, that have been long kept shut, there would sally out a warm smoke, and very thick, almost like that of a furnace, and sometimes the steam, that issues out, will be so gross and plentiful, that it has brought men into danger of being suffocated by it.

51. AND now, gentlemen, having shewn, that though experience be so confidently appealed to by the maintainers of Antiperistasis, yet she has not hitherto afforded them any thing, that much favours their cause; it remains, that I shew, that she bears witness against it. For besides that some passages of my late discourses do really contain phænomena, that not only do not favour Antiperistasis, but may justly be imployed as experiments against it, I shall *ex abundanti* (as they speak) present you with something, which I necessitated experience to supply me with, that seems expresly to overthrow it.

52. I MIGHT urge against those, who, though they begin to be ashamed of the doctrine of the schools, would establish an Antiperistasis upon the account of what they call a *fuga contrarii*, that the very instance they are wont to bring for their opinion, may be retorted upon them. For when they tell us, that in winter, the heat, to fly the cold of the external air, retires itself into the lower parts of the earth, and there harbours in cellars and wells, as may be proved by the smoking of water drawn from deep wells, which argues its heat, the vapours, which fly away, being, as vapours, hot in comparison of the outward air; we may easily answer, by demanding, why, if the heat, that was harboured in a smoking bucket of water, have the wit or instinct to fly from its contrary, it does not in the bucket, as it is said to do in the well, retire it self as far as it can from the surrounding cold of the ambient air; but instead of retiring to the innermost parts of the water (those being remotest from that) it needlesly flies abroad, with the vapours it excites, and does, as it were, of its own accord cast it self into the arms of the enemies it should shun. And indeed what I just now mentioned to you, as related to me by Dr. *Sam. Collins*, the great duke of *Muscovy*'s physician, does sufficiently manifest, that the cause, why the corpuscles, that keep cellars warm, abide beneath the surface of the earth in winter, is not that they fly the cold as their enemy, but that they are pent up beneath the ground; since, when vent is given them, they immediately rush into the open air, without fearing the cold even of *Russia* in the very midst of winter.

53. BUT I shall press this no further, but rather add, that the doctrine of Antiperistasis is as little beholden to the following experiment, which I sometimes tried, in order to the disabusing some abetters of *Themistius*. I took then an iron-rod, of about the bigness of a man's finger, having at one end of it a very broad and thick piece of iron (shaped almost like a spattule) that the quantity of the matter might, upon the ignition of the iron, make the heat very considerable: then having caused this thick end to be made red-hot in the fire, and having suddenly quenched it in cold water, I could not perceive, that the other end of the rod, by which it was wont to be held, did at all grow sensibly hot, as a favourer of Antiperistasis would have expected it should do to a very high degree, as presuming, that the innumerable particles of heat, that swarmed in the compact body of the red-hot part of the iron, must, to fly the cold of the water, retire in throngs towards the other extreme of the iron, and make it exceedingly hot. And lest any pre-existent warmth should hinder me from perceiving an increase of heat, in case any were produced in the handle of the iron, I caused it the next time the trial was made, to be kept in cold water; and yet even then, the immersion of the broad and candent end into the cold water brought as little of sensible heat to the other end, that I held in my hand, as it had done the time before; and having caused the experiment to be tried by another, the account I received was, that it succeeded with him, as it had done with me.

54. BUT this is not the main thing, gentlemen, that I intend to acquaint you with, there being an expedient, that I purposely devised to make one experiment, more considerable against Antiperistasis, than are the several mistaken observations of the Peripateticks to establish it.

55. I TOOK then a good sealed weather-glass, twelve or fourteen inches long, furnished with good spirit of wine, and having provied an open-mouthed glass of a convenient shape and size, and filled it but to a due height (that it might not afterwards run over) with common water, I so ordered the matter, that the stem of the thermoscope being supported by the cork, into which by a perforation or slit it was inserted, when the glass was stopped by the cork, the whole ball of the thermometer was immersed in the water, that filled the wide-mouthed glass, and did no where touch either the bottom or the sides of the glass, so that the ball or bubble was every way surrounded with water. The instrument being thus prepared, we observed at what station the ambient cold water had made the tincted spirit rest in the stem of the thermoscope; and then having provided a fit proportion of warm water in a commodiously shaped vessel, I removed the instrument into it, and placed it so, as that the external warm water reached to a convenient height on the outside of the open-mouthed glass: but though I carefully watched, whether the heat of the external water would increase or strike inwards the cold of that water, which did immediately incompass the ball of the weather-glass; yet I perceived no such matter, the tincted spirit in the stem keeping its station (without sinking beneath it) till the heat, after a while, having by de-

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grees being diffuſed through the formerly cold water, by the intervention of that now warmed, the tincted ſpitits in the thermometer began to aſcend.

56. AND to reduce the other part too of the doctrine of Antiperiſtaſis, to the determination of an experiment, the ſame thermoſcope was placed in the ſame wide-mouthed glaſs juſt after the former manner; only inſtead of the cold water, that, which immediately ſurrounded the glaſs, was warm; and when the warmth had impelled up the tincted ſpirit, till its aſcent began to be very ſlow, I immerſed the inſtrument to a convenient depth in a veſſel, that contained highly refrigerated water, mingled with divers pieces of ice. But notwithſtanding my watchfulneſs, it did not appear to me, that the water, that did immediately encompaſs the ball of the weather-glaſs, was at all increaſed or intended, by that liquor's being beſieged by water exceeding cold; for the languid motion of the tincted ſpirit upwards was not hereby ſo much as ſenſibly accelerated, (as it muſt have been conſiderably, if the heat of the internal water had been ſo augmented, or ſtruck inwards by the cold of the external, as the ſchools doctrine would have made one expect) but rather the aſcent was, by the chillingneſs of the contiguous water, quickly checked, and the formerly aſcending ſpirit was ſoon brought to ſubſide again. And to give myſelf the fuller ſatisfaction about ſome of the chief phænomena of this, and the former experiment, I had the curioſity to obſerve them more than once.

POSTSCRIPT.

A ſceptical Conſideration of the heat of cellars in winter, and their coldneſs in ſummer.

THE foregoing diſcourſes of *Carneades* ſeem to have ſufficiently ſhaken the foundations of the vulgar doctrine of Antiperiſtaſis, ſo far forth as it is ſuperſtructed upon the vulgar obſervations and phænomena, whereon men are wont to build it; and it ſeems to have made it alſo highly probable, that in caſe ſome of the examples wont to be produced in favour of Antiperiſtaſis ſhould prove hiſtorically true, yet thoſe phænomena may, more congruouſly to the wonted proceedings of nature, be explicated by the detention of calorifick or frigorifick corpuſcles, by the operation of the external cold or heat, than to a certain inexplicable ſelf-invigoration, which is commonly propoſed in ſuch a way, as inveſts inanimate bodies with the prerogatives of free agents. But though *Carneades* his adverſaries ſeem not to have well made out the hiſtorical part of the received doctrine concerning cold; yet upon an impartial ſurvey of what has been alledged on both ſides, I freely confeſs, that to me ſome of the matters of fact themſelves ſeem not yet ſo clearly determined as I could wiſh: for as to the obvious phænomena, that nature does, as it were, of her own accord preſent us, they ſeem to have been but perfunctorily conſidered, and our ſenſes only being the judges of them, we may eaſily, as *Carneades* argues, be impoſed upon by the unheeded prediſpoſitions of our organs. And as for contrived and artificial experiments, there ſcarce ſeem to have been any made fit to clear the difficulties, that invite me to ſuſpend my judgment, as to the grand queſtion (or fact) whether cellars, and other ſubterraneous places, be really hotter in winter than in ſummer.

IT is true, that I have ſcarce met with any point, wherein the modern ſchoolmen ſeem to have ſo much conſulted nature, as in this of Antiperiſtaſis. For enquiring what has been written of that ſubject, that may either confirm or oppoſe what has in the precedent dialogue been delivered about Antiperiſtaſis; I found, that the curiouſneſs and importance of the ſubject have made two or three of thoſe writers leſs negligent than I ſuſpected. But though I have lately met with in them an experiment or two, that ſeem cogently to evince, I do not ſay an Antiperiſtaſis in the ſenſe of the ſchools, but that ſubterraneal places are really hotter in winter than in ſummer, yet I muſt for a while longer continue my ſuſpenſion of judgment, which that even ſuch perſons, as are circumſpect themſelves, may not think unreaſonable, I will briefly ſubjoin the grounds of my ſcepticiſm about this matter.

FIRST then, the learned Jeſuit *Zucchius*, who is wont to be far more induſtrious than other Ariſtotelians (and on ſome ſubjects is careful to propoſe experiments, though he be not ſo clear and happy in expreſſing his thoughts) aſſures us ſomewhere, that having kept a good ſealed weather-glaſs, for three years together, in a good cellar, he found the water to riſe by the coldneſs of the ambient air in the ſummer, and to be depreſſed by the rarefaction of it in the winter; which ſeems undeniably to infer, that whatever be the reaſon of it, the heat in ſubterraneal places is indeed greater in winter than in ſummer. And another recent ſchoolman, who, as I am told, is of the ſame order, though the learned man publiſhed his little book under one of his diſciple's names, affirms, that he found by a weather-glaſs, that a well at the place, where he lived, was colder in ſummer, and hotter in winter. And theſe aſſertions of *Zucchius*, and the other Jeſuit, do, I confeſs, reſtrain me for a while from yielding a

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full aſſent to what *Carneades* hath delivered, as to the matter of ſubterraneal cold and heat. But on the other ſide, I am not hitherto reduced by theſe experiments, to declare with his adverſaries againſt him, becauſe of the following ſcruples.

FIRST then I conſider, that it is not univerſally true, which is wont to be indefinitely affirmed, and believed, that cellars and other ſubterraneal places are hotter in winter than in ſummer. For the inſtances produced by *Carneades* ſeem plainly enough to manifeſt the contrary, and my own obſervations made in a cellar with a ſealed weather-glaſs do keep me from diſſenting from *Carneades* as to that point. I would therefore make a diſtinction of ſubterraneal places; for ſome are deep, as the beſt ſort of cellars; others deeper yet, as the Hungarian mines, mentioned by *Carneades* out of *Morinus*; and ſome again are but ſhallow, as many ordinary cellars and vaults: of theſe three ſorts of ſubterraneal places, the deepeſt of all do not, as far as the authority of mineraliſts above alledged may be relied on (for I am yet inquiring further) grow hot and cold according to the ſeveral ſeaſons of the year, as the vulgar doctrine of Antiperiſtaſis requires, but are continually hot: the ſhallower ſort of ſubterraneal places, though by reaſon of their being fenced from the outward air, they are not ſo ſubject to the alterations of it, whether to heat or cold, as open places are; yet by reaſon of their vicinity to the ſurface of the earth, they are ſo far affected with the mutations, which the outward air is liable to in ſeveral ſeaſons of the year, that in winter, though they be warm in reſpect of the colder air abroad, yet they are really (at leaſt ſome of them) as far as I have tried, colder in very cold weather, and leſs cold in warm weather. And in this opinion I am confirmed by two things; the one, that having purpoſely inquired of the *Polonian* nobleman mentioned by *Carneades*, whether he had obſerved in his country, in ſharp winters ſmall beer would freeze in cellars, that were not very deep, but would continue fluid in thoſe that were, he aſſured me he had taken notice of it: The other thing is the confeſſion of the anonymous Jeſuit lately mentioned, who acknowledges, that he found but little difference between the temperature of the water in the well he examined in ſummer and in winter, though it were a conſiderably deep one; and adds a while after, that at *Florence*, where the ſubterraneal vaults are ſhallower, the air is obſerved to be colder in winter than in ſummer, though at *Rome*, in their deep cellars, the contrary has been found. So that the lowermoſt ſort of ſubterraneal cavities being, for aught appears, perpetually hot, and the upper or ſhallower ſort of them being colder, not hotter in cold weather than it is in warm, it is about the temperature of the middle ſorts of them, ſuch as are the deeper and better cellars, that the queſtion remains to be determined. And thus much of my firſt conſideration.

THE next thing I ſhall offer to be conſidered is this; that it is not ſo eaſy a matter, as even philoſophers and mathematicians may think it, to make with the weather-glaſſes hitherto in uſe, an experiment to our preſent purpoſe, that ſhall not be liable to ſome exception, eſpecially if the cellars or wells, where the obſervations are to be made, be very deep. For the gravity of that thick and vapid ſubterraneal air, and the greater preſſure, which the air may there have, by reaſon of its preſſing, according to an atmoſpherical pillar lengthened by the depth of the cellar or well, may, in very deep cavities, as well alter the height of the water in common weather-glaſſes, as heat and cold do, and ſo make it uncertain, when the mutation is to be aſcribed to the one, and when to the other; or at leaſt very difficult to determine diſtinctly, what ſhare is due to the preſſure, and what to the temperature of the air. And this uncertainty may be much increaſed by this more important conſideration, that not only in places, where the heights of the atmoſpherical cylinders are differing, the preſſures of the air upon the ſtagnant water in the weather-glaſſes may be ſo too, but even in the ſelf-ſame place, the inſtrument remaining unmoved, the preſſure of the atmoſphere may, as I have often obſerved, haſtily and conſiderably alter, and that without any conſtant and manifeſt cauſe (at leaſt that I could hitherto diſcover;) ſo that the erroneous eſtimate, that may be hereby ſuggeſted of the temperature of the air, can ſcarce poſſibly be avoided, without the help of a ſealed weather-glaſs, where the included liquor is ſubject to be wrought upon by the heat and cold, not preſſure of the air. So that to apply this to *Zucchius* his experiment, unleſs he had been aware of this, and unleſs I knew, that he had divers times made his obſervations, with the aſſiſtance of a ſealed weather-glaſs, it may be ſuſpected, that he might accidentally find the water in his common weather-glaſs (for ſuch a one it appears he uſed, as probably knowing no other) to be higher, when he looked on it in ſummer, than when he looked on it in winter, not becauſe really the ſubterraneal air was colder in the former ſeaſon, than in the latter, but becauſe the atmoſphere chanced then to be heavier. And when I remember, in how few hours I have ſometimes, and that not long ſince, obſerved the quickſilver, both in a good barometer, and even in an unſealed weather-glaſs furniſhed with quickſilver, to riſe almoſt an inch perpendicularly, without any manifeſt cauſe proceeding from cold; I cannot think it impoſſible, that in long weather-glaſſes furniſhed only with water, or ſome ſuch liquor, the undiſcerned alterations of the atmoſphere's preſſure, may produce very notable ones in the height of the water in ſuch inſtruments. But this is not all, that a jealous man might ſuſpect. For *Zucchius* having, for aught appears, made his obſervations but in one place, we are not ſure, but that may be one of thoſe, whereof there may be many, on which ſubterraneal exhalations have a peculiar, and not languid influence; as *Carneades* has towards the cloſe of his diſcourſe made probable, out of the relations of *Olaus Magnus*, and *Martinius*, touching the great and

See the ſecond preliminary diſcourſe, that accompanies the Hiſtory of Cold.

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and ſudden thaws, that ſometimes begin from the bottom, and thereby argue their being produced by copious ſteams, that aſcend from the lower parts of the terreſtrial globe; which may be further confirmed by what he formerly noted of the ſudden damps, that happen in many mines. But that, which is of the moſt importance about our preſent inquiry, remains yet to be mentioned; which is, that having had the curioſity to inquire, whether no body elſe had made experiments of the ſame kind; I find, that the learned *Maignan* had the ſame curioſity, that *Zucchius* had, but with very differing ſucceſs; and therefore, though this inquiſitive perſon do admit, in his diſputation about Antiperiſtaſis, a notion, that I confeſs I cannot approve, (ſince to aſcribe, as he does, a *fuga contrarii* * to cold and hot ſpirits, is, in my apprehenſion, to turn inanimate bodies into intelligent and deſigning beings;) yet he does juſtly and rationally reject, with *Carneades*, the vulgar doctrine of Antiperiſtaſis, and confirms his rejection of it by two experiments. For firſt, he ſays, that he found with a thermometer, that when in winter a cold northerly wind froze the water without doors, it was no leſs cold in wine-cellars, than it was at the ſame ſeaſon, and at the ſame hour of the day in his ſtudy, only the paper-ſhuts of his window, that regarded likewiſe the North, being put to. And though, if he had ſaid nothing elſe, I ſhould have ſuſpected, that this might have proceeded from the ſhallowneſs of the cellars he made his trial in; yet he prevents that ſuſpicion, by taking notice in one clauſe of his relation, that the cellars were of the very beſt of their kind, in which in ſummer the greateſt cold was wont to be felt. But his next experiment is yet more conſiderable, which I ſhall therefore deliver in his own words that follow: *Expertus ego ſum* (ſays he) *thermometro fideliſſimo, & à præcedente hyeme in ſequentem æſtatem prorſus invariato, inſtructo etiam tali aquâ, nempe in hoc ipſum ex præſcripto Trebellii, ita comparata, ut non exhaletur, neque minuatur; expertus (inquam) ſum in ſupradictis optimis cellis vinariis maximum, quod ardentiſſima æſtate fuit, frigus non adæquaſſe illud, quod ibidem erat brumali tempore, ut dixi in ſuperiori experimento, ſiquidem in tubo vitrei thermometri quatuor circiter palmos longo, & in octo gradus graduumque minuta diviſo, æqua hyeme aſcendit ad gradus 7. cum ſemiſſe, æſtate autem vix gradum ſextum ſuperavit, cum tamen ad ſenſum multo magis vigeret frigus iſtud æſtivum.*

Thus far this learned, as well as reſolute author, who ſeeming, by the mathematical part of his *Perſpectiva Horaria*, to be an accurate and induſtrious maker of obſervations, we may oppoſe this newly-recited experiment to that of *Zucchius*, which it flatly contradicts: and therefore ſince the depth of the cellars is of great moment in experiments of this nature; ſince alſo the particular parts of the place or ſoil, where the cellars or other cavities happen to be, may, in ſome caſes, not be inconſiderable; and ſince laſtly, neither *Zucchius* or *Maignan* ſeem to have been aware of the differing weights of the atmoſphere, in the ſelf-ſame place, (as not having ſeen the XVIIIth of our *Phyſico-mechanical Experiments*, before which I never ſaw nor heard of any thing publiſhed, or otherwiſe written to that purpoſe) I hope I ſhall be excuſed, if I retain ſome ſcruples about the hiſtorical queſtion I have been conſidering, till the experiment have been carefully made, for a competent ſpace of time in ſeveral places, and that not with common weather-glaſſes (like thoſe uſed by my two learned authors) wherein the liquor may be made to riſe and fall by the differing gravities of the air, but with ſealed thermoſcopes, wherein the alterations may more ſafely be ſuppoſed to proceed only from its heat and cold.

And to conclude, ſince *Carneades* has ſpeciouſly enough anſwered the other obſervations, that are wont to be produced in favour of the Ariſtotelian Antiperiſtaſis, if *Maignan*'s relation be better warranted by future experiments, than that of *Zucchius*, it will very much diſfavour the whole doctrine itſelf, which ſeeming to have been deviſed, but to give an account of the phænomena, to which it is wont to be applied, conſidering men will be but little invited to imbrace it, if the matter of fact be as little certain, as what is propoſed in the hypotheſis is intelligible.

* My backwardneſs to admit a *fuga contrarii* may be ſomewhat confirmed by what I lately learned from the Engliſh extraordinary ambaſſador (the earl of *Carliſle*) into *Ruſſia*, newly returned thence. For meeting the other day with an opportunity of asking his lordſhip a few queſtions (which he was pleaſed to anſwer with his wonted civility) about the cold in *Muſcovy*; I was informed by one of his anſwers, that his excellency had there the curioſity to obſerve ſome bottles of choice and ſtrong wine, that were vehemently frozen, and the opportunity to take notice, that the liquor was quite congealed throughout, and turned into ſolid ice: whence he rationally inferred, that the ſpirituous parts of wine did not in theſe bottles (for aught he acknowledged, that in greater veſſels, that may ſometimes hold true, which is ſaid of the production of ſpirit of wine by congelation) retire to the centre, and remain there unfrozen. And his lordſhip ingeniouſly purſued the experiment, and confirmed the conjecture, by cauſing the ice to be taken out of the broken bottles, to be thawed by degrees into ſeveral veſſels, by which means he found, that the liquor afforded by the exterior parts of the reſolved ice was very little, if a leſs ſtrong, than that, which was obtained from the internal parts of the ſame ice. From which obſervation *Carneades* would argue, that at leaſt it is not univerſal, but in particular caſes, and therefore probably by accident, or upon particular accounts, that the concentration of the ſpirits of liquors is conſequent upon being expoſed to cold.

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AN EXAMEN OF Mr. HOBBES's Doctrine touching COLD.

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THE author of the following diſcourſe intending it ſhould make a part of certain conſiderations upon the four famous hypotheſes, or opinions, of the Nature and Cauſe of Cold; which (conſiderations) he thought fit to reſerve for the latter end of the hiſtory of that quality, was invited to ſuppreſs it ever ſince the former part of the year, that preceded the laſt. And though this diſcourſe, (both for other reaſons, and becauſe he found it more ready and finiſhed, than ſome other papers, that belonged to the ſame part of the newly mentioned hiſtory) comes abroad unaccompanied; yet he judged it not amiſs, to intimate thus much, that the reader may be informed, upon what account Mr. *Hobbes*'s opinions come to be examined in an hiſtorical treatiſe; and may not wonder either to find, that divers paſſages of it are omitted, that are unfavourable enough to Mr. *Hobbes*'s doctrine, or to meet with in a diſcourſe poſtponed to the *Hiſtory of Cold* ſome experiments, that ſeem to argue it to have been written before they were caſt into the order, wherein they now appear. To this I have nothing to add, but that whereas through haſte the ſcheme referred to in the long citation out of Mr. *Hobbes*'s has not been added to the others, that belonged to this book, I am not much troubled at the omiſſion (as alſo that in other quotations the place is not always as well mentioned as the words,) becauſe, that if any ſhall be found, that after having conſidered, what I urge againſt the (great, but imaginary) intereſt, Mr. *Hobbes* would aſcribe to winds (whether he explicate their cauſes rightly or not) in the production of leſſer degrees of cold, but (how improbably ſoever) of congelation itſelf, ſhall think the ſight of that ſcheme of any importance; this learned man's book, *De Corpore*, is in ſo many hands, that any reader ſhall deſire it, may very eaſily have an opportunity to conſult the ſcheme in the particularly cited place.

1. MR. *Hobbes*'s Theory concerning Cold does to me, I confeſs, appear ſo inconſiderately pitched upon, and ſo ſlightly made out, that I ſhould not think it merited, eſpecially in an hiſtorical treatiſe, a particular or ſerious examination, but that in propoſing it, he ſcruples not to talk to his readers of his demonſtrations; and the preference he is wont to give himſelf above the eminenteſt, as well of modern as of ancient writers, has had no ſmall effect upon many, who not knowing, how indulgent ſome writers are wont to be to the iſſues of their own brain, as ſuch, are apt to miſtake confidence for evidence, and may be modeſt enough to think, that their not diſcerning a clearneſs in his explications and reaſonings, is rather a fault of their underſtandings, than of his doctrine. Mr. *Hobbes* delivers his theory in the ſeven firſt articles of the 28th chapter of the fourth part of his elements. But becauſe the whole diſcourſe is too long to be here tranſcribed, and becauſe in the 2d, 3d, and 4th ſections, that, which he treats of, is the generation of winds, and, that which he handles in the 5th, is the notion of a hard body; we may ſafely leave out thoſe four ſections, eſpecially ſince, though there be in them divers things about the motion of the ſun, and other matters, that are more ſtrongly aſſerted than proved, yet his doctrine tending but to ſhew, how the winds are generated, though it were granted, would make but very little, if any thing at all, towards the evincing of his theory about cold.

2. AND that we may not be ſuſpected to injure his opinion or his arguments, we will, though the citation will be ſomewhat prolix, firſt recite them, as himſelf delivers them in thoſe three ſections, that treat immediately of cold, and then we will ſubjoin our animadverſions on them.

3. [THESE things, ſays he, being premiſed, *Artic. 6.* I ſhall ſhew a poſſible cauſe, why there is greater cold near the pole of the earth, than further from them. The motion of the ſun between the tropicks, driving the air towards that part of the earth's ſuperficies, which is perpendicular under it, makes it ſpread itſelf every way; and the velocity of this expanſion of the air grows greater and greater, as the ſuperficies of the earth comes more and more to be ſtraitned; that is to ſay, as the circles, which are parallel to the equator, come to be leſs and leſs. Wherefore this expanſive motion of the air drives before it the parts of the air, which are in its way, continually towards the poles more and more ſtrongly, as its force comes to be more and more united, that is to ſay, as the circles, which are parallel to the equator, are leſs and leſs; that is, ſo much the more,

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by how much they are nearer to the poles of the earth. In thoſe places therefore, which are nearer to the poles, there is greater cold, than in thoſe, which are more remote from them. Now this expanſion of the air upon the ſuperficies of the earth from eaſt to weſt doth by reaſon of the ſun's perpetual acceſſion to the places, which are ſucceſſively under it, make it cold at the time of the ſun's riſing and ſetting: but as the ſun comes to be more and more perpendicular to thoſe cooled places, ſo by the heat, which is generated by the ſupervening ſimple motion of the ſun, that cold is again remitted, and can never be great, becauſe the action, by which it was generated, was not permanent. Wherefore I have rendered a poſſible cauſe of cold in thoſe places, that are near the pole, or where the obliquity of the ſun is great.

Artic. 7. 4. How water may be congealed by cold, may be explained in this manner. Let A (in the firſt figure) repreſent the ſun, and B the earth; A will therefore be much greater than B. Let E F be in the plain of the equinoctial, to which let G H I K and L C be parallel. Laſtly let C, and D, be the poles of the earth. The air therefore by its action in thoſe parallels will rake the ſuperficies of the earth, and that with a motion ſo much the ſtronger, by how much the parallel circles towards the poles grow leſs and leſs. From whence muſt ariſe a wind, which will force together the uppermoſt parts of the water, and withal raiſe them a little, weakening their endeavour towards the center of the earth. And from their endeavour towards the center of the earth, joined with the endeavour of the ſaid wind, the uppermoſt parts of the water will be preſſed together and coagulated; that is to ſay, the top of the water will be ſkinned over and hardened, and ſo again the water next the top will be hardened in the ſame manner, till at length the ice be thick. And this ice being now compacted of little hard bodies, muſt alſo contain many particles of air received into it. As rivers and ſeas, ſo alſo in the like manner may the clouds be frozen. For when by the aſcending and deſcending of ſeveral clouds at the ſame time, the air intercepted between them is, by compreſſion, forced out, it rakes, and by little and little hardens them. And though thoſe ſmall drops (which uſually make clouds) be not yet united into greater bodies, yet the ſame wind will be made; and by it, as water is congealed into ice, ſo will vapours in the ſame manner be congealed into ſnow. From the ſame cauſe it is, that ice may be made by art, and that not far from the fire; for it is done by the mingling ſnow and ſalt together, and by burying in it a ſmall veſſel full of water. Now when the ſnow and ſalt (which have in them a great deal of air) are melting, the air, which is preſſed out every way in wind, rakes the ſides of the veſſel; and as the wind by its motion rakes the veſſel, ſo the veſſel by the ſame motion and action congeals the water within it.

5. WE find by experience, that cold is always more remiſs in places, where it rains, and where the weather is cloudy (things being alike in all other reſpects) than where the air is clear. And this agreeth very well with what I ſaid before; for in clear weather the courſe of the wind, which (as I ſaid even now) raked the ſuperficies of the earth, as it is free from all interruption, ſo alſo it is very ſtrong. But when ſmall drops of water are either riſing or falling, that wind is repelled, broken and diſſipated by them; and the leſs the wind is, the leſs is the cold.

6. WE find alſo by experience, that in deep wells the water freezeth not ſo much, as it doth upon the ſuperficies of the earth. For the wind, by which ice is made, entering into the earth (by reaſon of the laxity of its parts) more or leſs, loſeth ſome of its force, though not much. So that if the well be not deep, it will freeze; whereas if it be ſo deep, as that the wind, which cauſeth cold, cannot reach it, it will not freeze.

7. WE find moreover by experience, that ice is lighter than water, the cauſe whereof is manifeſt from that, which I have already ſhown, namely, that the air is received in, and mingled with the particles of the water, whilſt it is congealing.

8. To examine now Mr. *Hobbes*'s theory concerning cold, we may in the firſt place take notice, that his very notion of cold is not ſo accurately, nor warily delivered. I will not here urge, that it may be well queſtioned, whether the tending outwards of the ſpirits and fluid parts of the bodies of animals do neceſſarily proceed from, and argue heat. Since in our pneumatical engine, when the air is withdrawn from about an included viper (to mention no other animals) there is a great intumeſcence, and conſequently a greater endeavour outwards of the fluid parts of the body, than we ſee made by any degree of heat of the ambient air, wont to be produced by the ſun. This, I ſay, I will not inſiſt on, but rather take notice, that though Mr. *Hobbes* tells us, that to cool, is to make the exterior parts of the body endeavour inwards; yet our experiments tell us, that when a very high degree of cold is introduced, not only into water, but into wine, and divers other partly aqueous liquors, there is a plain intumeſcence, and conſequently endeavour outwards of the parts of the refrigerated body. And certainly cold having an operation upon a great multitude and variety of bodies, as well as upon our ſenſories, he, that would give a ſatisfactory definition of it, muſt take into his conſideration divers other effects, beſides thoſe it produces on human bodies. And even in theſe, he will not eaſily prove, that in every caſe any ſuch endeavour inwards from the ambient ætherial ſubſtance, as his doctrine ſeems to ſuppoſe, is neceſſary to the perception of cold; ſince, as the mind perceives divers other qualities, by various motions in the nervous or membranous parts of the ſentient; ſo cold may be perceived, either by the decrement of the agitation of the parts of the object, in reference to thoſe of the ſenſory; or elſe by ſome differing impulſe of the ſenſitive parts occaſioned by ſome change made in the motion of the blood or ſpirits, upon the deadening of that motion; or by the turbulent motion of thoſe excrementitious ſteams, that are wont, when the blood circulates as nimbly,

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nimbly, and the pores are kept as open as before, to be diſſipated by inſenſible tranſpiration.

9. It may afford ſome illuſtration to this matter to add, that having inquired of ſome hyſterical women, who complained to me of their diſtempers, whether they did not ſometimes find a very great coldneſs in ſome parts of their heads, eſpecially at the top, I was anſwered, that they did ſo; and one of them complained, that ſhe felt in the upper part of her head ſuch a coldneſs, as if ſome body were pouring cold water upon it. And having inquired of a couple of eminent phyſicians, of great practice, about this matter, they both aſſured me, that many of their hyſterical patients had made complaints to them of ſuch great coldneſs in the upper part of the head, and ſome alſo along the vertebra's of the neck and back. And one of theſe experienced doctors added, that this happened to ſome of his patients, when they ſeemed to him and to themſelves to be otherwiſe hot. The noble * *Avicen* alſo ſomewhere takes notice, that the invenomed bitings of ſome kinds of ſerpents, (creatures too well known in the hot countries, where he lived) made thoſe, that were bitten by them, either become or think themſelves very cold. But that will perhaps ſeem more remarkable, which I ſhall further add, namely, that I know a nobleman, who followed the wars in ſeveral countries, and has ſignalized his valour in them; and yet though his ſtature be proportionate to his courage, yet when this perſon falls (as frequently he has done) in a fit of the ſtone, he feels an univerſal cold over his whole body, juſt like that, which begins the fit of an ague. And though he aſſures me, that the ſtones, that torment him, and which he uſually voids, are but very ſmall; yet whilſt the fit continues, which oftentimes laſts many hours, he does not only feel an extraordinary coldneſs, but which is more ſtrange, and which I particularly inquired after, cannot by clothes, or almoſt any other means, keep himſelf warm.

10. I Elsewhere take notice of ſome other obſervations, agreeable to theſe, by ſome of which we may be perſuaded, that there may be other ways, beſides thoſe already mentioned, of perceiving cold, though the outward parts of our bodies were not preſſed inwards. And whereas Mr. *Hobbes* infers that he, who would know the cauſe of cold, muſt find by what motion or motions the exterior parts of any body endeavour to retire inwards, that ſeems but an inconſiderable direction. For in compreſſions, that are made by ſurrounding bodies, there is produced an endeavour inward of the parts of the compreſt body, though no cold, but ſometimes rather heat be thereby generated. And I hope Mr. *Hobbes* will not object, that in this caſe the parts do not retire, but are thruſt inwards, ſince, according to him, no body at all can be moved, but by a body contiguous and moved. But what I have hitherto taken notice of, being chiefly deſigned to ſhew, that the notion of cold in general is not ſo obvious a thing to be rightly pitched upon, as many think, and that therefore it needs be no wonder, that it hath not been accurately and warily propoſed by Mr. *Hobbes*; I ſhall not any further proſecute that diſcourſe, but proceed to what remains. Next then, the cauſe he aſſigns, why a man can blow hot or cold with the ſame breath, is very queſtionable; partly, becauſe he ſuppoſes in part of the breath ſuch a ſimple motion, as he calls it, of the ſmall particles of the ſame breath, as he will not eaſily prove, and as † eminent aſtronomers and mathematicians have rejected; and partly, becauſe that without the ſuſpected ſuppoſition, I could (by putting together the conjectures of two learned writers, and what I have elſewhere added of my own) give a more probable account of the phænomenon, if I had not ſome ſcruples about the matter of fact itſelf: which laſt cauſe I add, becauſe, though I am not ſure, that further trials may not ſatisfy me, that the wind or breath, that is blown out at the middle of the compreſſed lips, has in it ſuch a real coldneſs, as men have generally aſcribed to it, yet hitherto ſome trials, that my jealouſy led me to make, incline me to ſuſpect, there may be a miſtake about this matter, and that in eſtimating the temper of the produced wind, our ſenſes may impoſe upon us. For having taken a very good and tender ſealed weather-glaſs, and blown upon it through a glaſs pipe (of about half a yard long) that was choſen ſlender, to be ſure, that my breath ſhould iſſue out in a ſmall ſtream; by this wind beating upon the ball of the weather-glaſs, I could not make the included ſpirit of wine ſubſide, but manifeſtly, though not much, aſcend, though the wind, that I preſently blew through the ſame pipe, ſeemed ſenſibly cold, both to the hand of by-ſtanders, and to mine own, and yet mine was more than ordinarily cold. So that having no great encouragement to enter into a diſpute about the cauſe of a phænomenon, whoſe hiſtorical circumſtances are not yet ſufficiently known and cleared, I will now proceed to add, that whatever be the cauſe of the effect, there are divers things that make Mr. *Hobbes*'s hypotheſis of the cauſe of cold unfit to be acquieſced in. For we ſee, that the grand cauſe he aſſigns of cold and its effects, is wind, which, according to him, *is air moved in a conſiderable quantity, and that either forwards only, or in an undulating motion:* and he tells us too, that when the breath is more ſtrongly blown out of the mouth, then is the direct motion prevalent (over the ſimple motion) which, ſays he, makes us feel cold; for, ſays he, the direct motion of the breath or air is wind, and all wind cools or diminiſhes former heat. To which words in the very next line he ſubjoins, that not only great, but almoſt any ventilation, and ſtirring of the air doth refrigerate. But againſt this doctrine I have ſeveral things to object. Chap. 28. Sect. 2. *at the beginning.*

11. For firſt, we ſee there are very hard froſts, not only continued, but oftentimes begun, when the air is calm and free from winds; and high and boiſterous ſoutherly winds are not here wont to be near ſo cold as far weaker

* Quoted by *Paul Neweraatz. De Purpura*, cap. 12.

† Dr. *S. Ward*, (now the worthy biſhop of *Exeter*) and Dr. *Wallis*, the learned Savilian profeſſor of Geometry, &c.

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weaker winds, that blow from the North-east.

12. NEXT, if Mr. *Hobbes* teach us, that it is the direct motion of the ſtream of breath, that is more ſtrongly blown out, that makes us feel cold, he is obliged to render a reaſon, why in an æolipile with a long neck, the ſtream that iſſues out, though oftentimes far ſtronger than that, which is wont to be made by compreſſing the lips, at a pretty diſtance from the hole it iſſues out of, is not cold, but hot.

13. THIRDLY, Mr. *Hobbes* elſewhere teaches, that when in our engine the pump has been long employed to exhauſt, as we ſay, the receiver, there muſt be a vehement wind produced in that receiver; and yet by one of our other experiments it appeared, that for all this in a good ſealed weather-glaſs placed there, before the included air begins to be, as we ſay, emptied, there appeared no ſign of any intenſe degree of cold produced by this ſuppoſed wind, ſo that either the wind is but imaginary, or elſe Mr. *Hobbes* aſcribes to winds, as ſuch, an infrigidating efficacy, that does not belong to them.

14. FOURTHLY, we find by experience, that in hard froſts water will freeze, not only though there be no wind ſtirring in the ambient air, but though the liquor be kept in a cloſe room, where, though the wind were high abroad, it could not get admittance; and ſome of our experiments, carefully made, have aſſured us, that water ſealed up in one glaſs, and that glaſs kept ſuſpended in another glaſs carefully ſtopt, to keep out not only all wind, but all adventitious air, may, nevertheleſs be not only much cooled, but turned into ice.

See the 6th Section of the Hiſtory of Cold.

15. FIFTHLY, We found by other experiments, that a frozen egg, though ſuſpended in, and perfectly ſurrounded with water, where no wind can come at it, will be every way cruſted over with ice; in which caſe there is no probability, that the ice ſhould be generated according to the way propoſed by Mr. *Hobbes*. For he will ſcarce prove, nor is there any likelihood, that a wind pierced the ſhell and cloſer coats of the egg to get into the contained liquors, and freeze them: and a more unlikely aſſertion it would be, to pretend, (as he, that maintains Mr. *Hobbes*'s doctrine, muſt) that ſo very little air, if there be any, as is mingled with the juices of the egg, is, by the cold, which is not wont to expand air (nor water, till it be ready to make it freeze) turned into a wind ſubtile enough, freely to penetrate the ſhell and coats of the egg, and great enough to diffuſe itſelf every way, and turn on every ſide the neighbouring water into ice; and all this notwithſtanding, that not only it appeared not by bubbles breaking through the water, that there is any adventitious air, that comes out of the egg at all; but that alſo, ſuppoſing there were ſome ſuch contained in the egg, yet what ſhadow of reaſon is there to conceive, that the air which was ingaged in, and ſurrounded with the ſubſtances of the white, and the yolk of the egg, muſt needs be a wind, ſince, according to Mr. *Hobbes*, that requires a conſiderable motion of moſt of the parts of the moved air the ſame way, and, according to him alſo, a body cannot be put into motion, but by another body contiguous and unmoved.

16. SIXTHLY, Mr. *Hobbes* does indeed affirm, that all wind cools, but is ſo far from proving, that the higheſt degrees of cold muſt needs proceed from wind, that he does not well evince, that all winds refrigerate. Nor are we bound to believe it without proof, ſince wind being, according to him, but air moved in a conſiderable quantity, either in a direct or undulating motion, it does not appear, how motion ſhould, rather than reſt, make air grow cold. For though it be true, that uſually winds ſeem cold to us; yet, in the firſt place, it is not univerſally true, ſince ſome, that have travelled into hot countries, and particularly the learned * *Alpinus*, have complained, that the winds coming to them in the ſummer from more torrid regions have appeared to them almoſt like the ſteam, that comes out at the open mouth of a heated oven. And if † *Marcus Polus Venetus* be to be credited, (for I mention his teſtimony but *ex abundanti*) the ſouthern winds near *Ormus* have been ſometimes ſo hot, as to deſtroy an army itſelf at once. And ſecondly, even when the wind does feel cold to us, it may oftentimes do ſo but by accident; for, as we elſewhere likewiſe teach, the ſteams, that iſſue out of our bodies being uſually warmer than the ambient air, (whence in great aſſemblies, even thoſe, that are not thronged, we find it exceeding hot, and I have ſeveral times obſerved a hot wind to come from thoſe throngs, and beat upon my face,) and the more inward parts of our bodies themſelves being very much hotter than the ambient air, eſpecially that, which is not yet full of warm ſteams, the ſame cauſes, that turn air into a wind, put it into a motion, that both diſplaces the more neighbouring and more heated air, and alſo makes it pierce far deeper into the pores of the ſkin, whereby coming to be ſenſible to thoſe parts, that are ſomewhat more inward than the cuticula, and far more hot, the air turned into wind ſeems to us more cold, than the reſtagnant air, (if I may ſo ſpeak) upon ſuch another account, as that, upon which, if a man has one of his hands hot, and another not, the ſame body that will appear lukewarm to this, will appear cold to the other; becauſe, though the felt body be the ſame, yet the organs of feeling are differently diſpoſed. And to confirm this doctrine by an experiment, (which has ſucceeded often enough, and need not ſucceed always

See this difficulty more largely handled in the firſt preliminary diſcourſe.

* *Euri, auſtrique flanti, à meridie loca arenoſa ſummoque calore inflammata tranſiimus, atque Ægyptum ſpiravit, tantum caloris æſtus, pulveremque & inflammatarum arenarum evehunt, ut ignitas fornacis flammas, nec non pulveribus abſtruſiſſimas nubes eo aſportaſſe videatur.* And elſewhere: *Prima æſtatis parte calidiſſima inæqualiſſimaque ob vehementiſſimum meridionalium ventorum calorem*, &c. Proſper Alpinus *de Medicina Ægyptiorum.*

† From nine till noon, there blows a wind with ſuch extreme heat from the ſands, that it ſwallows up a man's breath, and ſtifleth him. The King of *Chermain* ſent an army of ſixteen hundred horſe, and five thouſand foot, againſt the Lord of *Ormus*, for not paying his tribute, which were all ſurpriſed and ſtifled with that wind. *Marcus Polus* in *Purchas's Pilgrims*, *lib.* III. *p. m.* 71.

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always to ſerve our preſent purpoſe) we will add, that though air blown through a pair of bellows upon one's hand, when it is in a moderate temper, will ſeem very cold; yet, that the ambient air by being thus turned into wind, does indeed acquire a relative coldneſs, ſo as to ſeem cold to our ſenſes, but yet without acquiring ſuch a cold as is preſumed, may appear by this, that by blowing the ſame air with the ſame bellows upon weather-glaſſes, though made more than ordinarily long, and by an artiſt eminent at making them, we could not obſerve, that this wind's beating upon them did ſenſibly refrigerate either the air, or the liquor. Though it is not impoſſible, but that in ſome caſes the wind may cool even inanimate bodies, by driving away a parcel of ambient air, impregnated with exhalations leſs cold, than the air that compoſes the wind. But this is not much, if at all, more than would be effected, if, without a wind, ſome other body ſhould precipitate out of the air near the weather-glaſs, the warmer effluvia we have been mentioning; eſpecially if the precipitating body introduce in the room of the diſplaced particles, ſuch as may in a ſafe ſenſe be term'd frigorifick.

17. SEVENTHLY, nor can we admit, without a favourable conſtruction, Mr. *Hobbes*'s way of expreſſing himſelf, where he ſays, as we have lately ſeen, that all wind cools or diminiſhes former heat. For if we take heat in the moſt common ſenſe, wherein the word is uſed, not only by other writers, but alſo by philoſophers, to make wind the adequate cauſe of cold, it muſt in many caſes do more than diminiſh former heat. For water, for inſtance, that is ready to freeze, is already actually cold in a high degree, and yet the wind (if Mr. *Hobbes* will needs have that to be the efficient of freezing,) muſt make this not hot, but already very cold liquor, more cold yet, before it can turn into ice.

18. THESE things thus eſtabliſhed, it will not be difficult to diſpatch the remaining part of Mr. *Hobbes*'s theory of cold. For, to proceed to his ſixth ſection, we ſhall paſs by what a coſmographer would perhaps except againſt in his doctrine about the generation and motion of the wind upon the ſurface of the earth, and ſhall only take notice in the remaining part of that ſection of thus much: That the moſt of what Mr. *Hobbes* here ſhews us, is but, that there is an expanſion of the air, or a wind generated by the motion and action of the ſun; but why this wind thus generated muſt produce cold, I do not ſee, that he ſhews; nor does his affirming, that it moves towards the poles, help the matter. For beſides that we have ſhewn, that wind, as ſuch, is not ſufficient to produce far leſs degrees of cold, than thoſe, that are felt in many northern regions, there muſt be ſome other cauſe, than the motion of the air or ſteams driven away by the ſun, to make bodies, not in themſelves cold, (for ſo they were ſuppoſed not to be, when the ſun began to put them in motion) become vehemently cold in their paſſage. For Mr. *Hobbes* cannot, as other naturaliſts, derive the coldneſs of freezing winds from the cold ſteams they meet with, and carry along with them in their paſſage through cold regions; ſince then thoſe ſteams rather than the wind would be the cauſe of that vehement coldneſs; and ſo it might juſtly be demanded, whence the coldneſs of theſe cold exhalations proceeds. Beſides that, it is very precarious and unconſonant to obſervation, to imagine ſuch a wind, as he talks of, to blow, whenever great froſts happen, ſince, as we noted before, very vehement glaciations may be obſerved, eſpecially in northern regions, when the air is calm, and free from winds.

19. THE account he gives in his ſeventh ſection of turning water into ice, is the moſt unſatisfactory I have ever yet met with; for a good part of that ſection is ſo written, as if he were afraid to be underſtood. But whereas he ſuppoſes, that by the endeavour of the wind to raiſe the parts of the water, joined with the endeavour of the parts of the water towards the center of the earth, the uppermoſt parts of the water will be preſt together, and coagulated, he ſays that which is very far from ſatisfactory. For, firſt, ice is often produced, where no wind can come to beat upon the uppermoſt parts of the water, and to raiſe them; and in veſſels hermetically ſealed, which exactly keep out air and wind, ice may be generated, as many of our experiments evince. And this alone were a ſufficient anſwer, ſince the whole explication is built upon the action of the wind. But this is not all we have to object; for not to urge, that he ſhould have proved, that the uppermoſt parts of the water muſt be raiſed in congelation, eſpecially ſince oil, and divers other liquors, are contracted by it; not to urge this, I ſay, what ſhew of probability is there, that by the bare endeavour of the wind, and the gravity of the ſuperficiate parts of the water, there ſhould be any ſuch forcible compreſſion made, as he is pleaſed to take for granted? And yet this itſelf is leſs improbable, than that ſuppoſing the uppermoſt parts of the water to be preſſed together, that preſſure is ſufficient to coagulate, as he ſpeaks, or rather congeal them into ice. So bold and unlikely an aſſertion ſhould at leaſt have been countenanced by ſome plauſible reaſon, or an example in ſome meaſure parallel. For I remember not any one inſtance, wherein any degree of compreſſion, that has been imployed, much leſs ſo ſlight a one as this muſt be, conſidering the cauſes, whence it is ſaid to proceed, can harden any liquor, into ice, or any other hard body. And in the experiment, we have elſewhere mentioned, of filling a pewter-veſſel with water, and when it is exactly cloſed, compreſſing it by the knocks of a hammer, till the water be reduced to penetrate the very pewter, we found not that ſo violent a compreſſion did give the water the leaſt diſpoſition to turn a hard body. And as for the way Mr. *Hobbes* aſſigns of increaſing the thickneſs of ice, it is very difficult to conceive, how a cake of ice on the top of the water, being hard frozen to the ſides of the containing veſſel, and thereby ſevering betwixt the

In the new experiments touching the ſpring of the air.

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the included water and the external air; the wind, that cannot come to touch the water, because of the interpoſition of the hard and rigid ice, ſhould yet be able, ſometimes at the depth of nine or ten foot, or much further, to beat upon the ſubjacent water, and turn it into ice. And it is yet more difficult to conceive, how the wind muſt do all this, when, as was lately noted, the water doth freeze more and more downwards, to a great depth, in places where the wind cannot come to beat upon it at all. And as to what Mr. *Hobbes* further teaches, that the ice muſt contain many particles of air received into it, we have elſewhere occaſion to ſhow, how erroneouſly he diſcourſes about thoſe icy bubbles.

See the 9th Title of the Hiſtory of Cold.

20. THE reaſon he aſſigns of the freezing of water with ſnow and ſalt, does as little ſatisfy as the reſt of his theory of cold. For not to mention, that he affirms, without proving it, that ſnow and ſalt have in them a great deal of air; it is very precarious to aſſert, that this air muſt be preſt out every way in wind, which muſt rake the ſides of the veſſel: for it is ſtrange, that far more diligent obſervers than Mr. *Hobbes* ſhould take no notice of any ſuch wind, if any ſuch wind there were. But this is yet leſs ſtrange than that which follows; namely, that this wind muſt ſo rake the ſides of the veſſel, as to make the veſſel, by the ſame motion and action, congeal the water within it: for what affinity is there between a wind paſſing along the outſide of a glaſs, altogether impervious to it, and the turning a fluid body, included in that glaſs, into a hard and brittle body? The wind indeed may, perhaps, if it be ſtrong, a little ſhake or agitate the particles, that compoſe the glaſs, and thoſe may communicate ſome of their motion to the contiguous parts of the water: but why all this muſt amount to the turning of that water into ice, is more, I confeſs, by far than I can apprehend; eſpecially ſeeing, that though you long blow upon a glaſs of water with a pair of bellows, where there is not an imaginary wind, as Mr. *Hobbes*'s, but a real and manifeſt one; yet the water will be ſo far from being frozen, that our formerly mentioned experiments (of blowing upon thermometers) make it probable, that it will ſcarce be cooled. And if ſea-ſalt do contain ſo much air, by vertue of which, it, as well as the ſnow, produces ſo intenſe a degree of cold, how chance, that being reſolved in a little water without ſnow, it does not produce at leaſt a far greater degree of cold than we find it to do? Beſides, in the experiment we made (and elſewhere mention) of freezing water ſealed up in bubbles, though the bubbles were ſuſpended in other glaſſes, whoſe ſides nowhere touched them, and the remaining part of whoſe cavities were filled ſome with air, and ſome with unfreezing liquors; what likelihood is there, that Mr. *Hobbes*'s inſenſible wind ſhould be able to occaſion ſo many ſucceſſive rakings through different bodies, as there muſt be, to propagate the congelative motion (if I may ſo call it) of the wind, through the firſt glaſs, to the included air or liquor, and through that new medium to the glaſs containing immediately the water, and through that to the innermoſt parts of the ſealed up water? And it might be further objected, if it were worth while, that Mr. *Hobbes* does not ſo much as offer at a reaſon, why ſpirit of wine, aqua fortis, or even brine, if it be of the ſtrongeſt ſort, are not either by this mixture, or (here in *England*) by the wind in open air, turned into ice, as well as many other liquors are.

See the 4th Section of the Hiſtory of Cold.

21. THE reaſon, why cold is wont to be more remiſs in rainy or cloudy weather, than in that which is more clear, is not better given by Mr. *Hobbes*, than by ſome others, that have written before him: for, not to mention, that I have ſeen great froſts, and laſting enough in cloudy, and ſometimes very dark weather; that which he talks of the wind's being more ſtrong in clear weather than in cloudy, is of no great importance; ſince common experience ſhews, that in clear weather the air may be very cold, and the froſt very great, where no wind is felt to rake (as he would have it) the ſuperficies of the earth. Nor does experience bear witneſs to what he not warily enough pronounces, that the leſs the wind is, the leſs is the cold. There are but two phænomena more, which in this ſection Mr. *Hobbes* pretends to explicate: the one is, that in deep wells the water does not freeze ſo much, as it does upon the ſuperficies of the earth. But the reaſon of this we elſewhere take occaſion to conſider, and therefore in this place we need only note, that Mr. *Hobbes* has not rightly aſſigned it, by aſcribing it to the wind's entring more or leſs into the earth, by reaſon of the laxity of its parts; ſince beſides that it is very improbable, that the wind ſhould not, as he ſays it does not, loſe much of its force by entring into the earth at its pores, and other leſſer cavities (for that ſeems to be his meaning by the laxity of the earth's parts) to ſo great a depth as water lies in ſeveral wells ſubject to freezing: beſides this, I ſay, experience teaches us, that wells may be frozen, though their orifices be well covered, and the wind be thereby kept from approaching the included water by divers yards; and very many wells, that are ſubject to freeze, when northerly and eaſterly winds reign, will likewiſe be frozen in very cold winters, whether any winds blow, or not.

See the Examen of Antiperiſtaſis.

22. THE other, and laſt phænomenon, Mr. *Hobbes* attempts to explicate, is, that ice is lighter than water. The cauſe whereof, ſays he, is manifeſt from what I have already ſhown; namely, that air is received in, and mingled with the particles of the water, whilſt it is in congealing. But that this is not the true reaſon, may be argued from hence, that if a convenient glaſs-veſſel be filled topfull with water, and expoſed either unſealed or ſealed to congelation, the ice will have ſtore of bubbles, which, at leaſt in the ſealed veſſel, cannot by Mr. *Hobbes*, who will not affirm glaſs to be pervious to the air, be pretended to proceed from bubbles, that got from without into the water, whilſt it was in congealing. And we have ſometimes had occaſion to manifeſt, by particular experiments purpoſely made, how little of air there is even in thoſe bubbles, that

See the 9th Title of the Hiſtory of Cold.

are

are generated in ice, made in veſſels, where the air was not kept from being contiguous to the water.

23. And thus have we gone through Mr. *Hobbes*'s theory of cold. In his propoſing of which, we wiſh'd he had in divers places been more clear; and in our curſory examination of which we have ſeen, that moſt of the particulars are either precarious or erroneous; and were they neither, yet the whole theory would, I fear, prove very inſufficient. Since an attentive reader cannot but have marked, that this learned author has paſt by far the greateſt part even of the more obvious phænomena of cold, without attempting to explicate them, or ſo much as ſhewing in a general way, that he had conſidered them, and thought them explicable by his hypotheſis: by which he, that will fairly explain all the phænomena recited in the notes we have been drawing together, and which yet contain but a beginning of the Hiſtory of Cold, ſhall give me a very good opinion of his ſagacity.

A POSTSCRIPT.

THOUGH the haſte I am obliged to comply with, keep me from annexing the hiſtorical papers, wherewith I had thoughts to conclude this book, concerning cold; yet ſince the nature of the paſt Examen gave me but little opportunity to teach the reader any thing more conſiderable, than that Mr. *Hobbes*'s doctrine is erroneous; I am very inclinable to make him here ſome ſuch little amends, as the time will permit, for that paucity of experiments. And therefore ſince in the laſt ſection of the foregoing Hiſtory, upon occaſion of an experiment very imperfectly, and not intelligibly delivered by *Berigardus*, I intimate my having elſewhere plainly ſet down either the ſame he meant, or one of that nature, and that with conſiderable phænomena unmentioned by him; I chuſe rather to borrow ſome account of it from another treatiſe, to which it belongs, than not to gratify ſome of the curious to whom the phænomena I ſhew'd them of it, ſeemed no leſs pretty than ſurprizing.

The way then I uſed in making this experiment, may be gathered from the following directions.

Take of good unſlaked lime three parts (or * thereabouts) of yellow orpiment one part, of fair water 15 or 16 parts; beat the lime groſly, and powder the orpiment, (with care to avoid the noxious duſt, that may fly up †) and having put theſe two ingredients into the water, let them remain there for two or three hours, or longer, if needs be, remembring to ſhake or ſtir the mixture from time to time. By this means you will obtain a ſomewhat fetid liquor, whereof by warily decanting, or by filtrating it, the clear part muſt be ſever'd from the reſt.

In the mean time, take a piece of cork, and having lighted it ſo, that it is kindled throughout, remove it from the fire, whilſt it is yet burning, and by a quick immerſion quench it in fair water. And having by this means reduced it to a coal, you may (in caſe you have not erred in the operation) by grinding it with a convenient quantity of gum-water ‡, bring it to the colour and conſiſtence of a good black ink, that you may uſe with an ordinary pen.

Whilst theſe things are doing, you may take what quantity you think fit of common minium **, and two or three times its weight of ſpirit of vinegar, (which needs not be for this purpoſe much ſtronger than phlegm, and to which even undiſtilled vinegar may be a ſuccedaneum) and putting the powder and liquor into a glaſs-phial, or any other convenient veſſel, let them infuſe over hot embers, or in ſome conſiderably warm place for two or three hours more or leſs, till the liquor have acquired a very ſweet taſte.

All things being thus prepared, take a new, or at leaſt a clean pen, and write with it ſome ſuch thing, as you either deſire or need not fear to have read, between (if you pleaſe) or, which is ſafer, †† over the lines, which contain your ſecret, and which are to be traced with the ſolution of minium; for this liquor, if it be either well decanted or filtred, will be ſo clear, that what is written with it by a new pen, will not be ſeen on the paper when it is dry.

Lastly, When you would ſhow the experiment, dip a ſmall piece of ſponge, or a linnen-rag (or, for a need, a little paper wreathed) in the water, that was made with lime and auripigmentum, and with this liquor, which,

* According to the goodneſs of the lime, of which, if it be very ſtrong, two parts may ſerve the turn; and which, if it be too weak, may make the experiment miſcarry.

† To prevent which, I uſually cauſe the orpiment to be beaten, wrapt up in divers papers, or ſome other way ſecured from avolation, and from harming the veſſel wherein it is pounded.

‡ Which for this uſe it will ſuffice to make by diſſolving gum-arabick in a little fair water.

** This is known in the ſhops by the name of red-lead, and is here ſpecified, as being cheap and eaſy to be procured, though I ſuppoſe, that other calxes or powders of the ſame metal, if they be not ſophiſticated, may ſerve the turn.

†† If you write firſt with the black ink, and then with the ſolution, the lines muſt be made ſomewhat diſtant, that thoſe, which expreſs your ſecret, may have room between the others; and therefore the better to avoid ſuſpicion, I choſe rather to write firſt with the inviſible ink, and then over that with the black, as if I had writ on an ordinary piece of white paper, by which means I could write the black lines as cloſe as I pleaſed.

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which, though it ſmell ill, will look limpid and clear, wiping over the paper, it will preſently, at once, both wipe out or obliterate what was written with the black ink, and make all that was written with the inviſible ink, though perhaps in the ſelf-ſame lines, appear black, ſo as to be very eaſily and plainly legible.

This is the way, to which many years ago my trials led me, of making this odd experiment. For the performing whereof, if any can propoſe a more eaſy and better way, (for I find by an inquiſitive * traveller, that there are more ways than one) I ſhall willingly learn it. In the mean time, the reader may perceive, that I did not cauſleſly intimate, that the learned *Berigardus*, though he would manifeſt a great thing in philoſophy by this experiment, did yet either not underſtand himſelf that part of it he pretends to teach, or has omitted one of the main ingredients of the water of orpiment he ſpeaks of. For I did not find, that even by a long infuſion, nor by ſome decoction of the orpiment alone (without the quick-lime) there would be produced a liquor, either obviouſly fetid, or that would perform ſo much as a leſs matter, than what that, which he mentions, ſhould. And whereas he ſeems to commend this way (though but between lines written with common ink) for the writing of things one would not have to be diſcovered, and though I have yet met with nobody, that having ſeen the experiment, is not of his mind; yet I remember, that when, many years ago, I was making trials concerning the ſeveral ways of making inviſible inks, my conjectures led me to diſcover, that I could very readily bring what was written, with a ſolution of minium, to be legible by the help of a fire; as well as I could alſo detect by the ſame way ſeveral inviſible inks, which are believed to require appropriated liquors to make them confeſs their ſecrets. But I muſt reſerve the reflections, and other particulars, that relate to this experiment, for the treatiſe, to which it belonged. Only I will now add, that beſides the above-ſpecified motives to communicate what I have at preſent written of it, I was the rather induced to do ſo, becauſe I had mentioned, but not taught this experiment, in the Hiſtory of Whiteneſs and Blackneſs; and becauſe alſo *Berigardus* is not the only author of note I have met with, that having made particular mention of the experiment, has given the curious but a lame and unſatisfactory account of it.

A N

ADVERTISEMENT to the READERS OF THE Following EXPERIMENTS, by the Author of the foregoing Hiſtory.

AT the ſame time that the Royal Society required of me an account of what I had obſerved, or tried, concerning Cold †, they recommended the making of trials about that ſubject to the learned Dr. *C. Merret*, who having diſpatched what he intended, much earlier than I could bring in my far more voluminous papers, he long ago preſented his to that Illuſtrious Company: and ſince that, has thought fit to let them indear my treatiſe, by their being annexed to it, and compoſing a part of it; and that ſuch a part, as much might be ſaid of it, if after I have informed the reader of its having obtained the thanks of a ſociety, that is too much accuſtomed to receive and produce excellent things, to be ſuſpected of valuing trifles, I could think it needful and proper to give thoſe papers any other elogium. And it falling out fortunately enough, that the doctor and I (being at ſome miles diſtance) did not communicate our deſigns to one another; as I knew nothing what he had been doing, till I heard it publickly read at *Greſham-College*, when far the greateſt part of my experiments were (as is known to more perſons than one) already recorded; ſo I afterwards ſcrupulouſly abſtained from borrowing the trials mentioned in his papers, to inrich mine. Which forbearance was the more eaſy to me, becauſe after the firſt time I heard thoſe papers read, I never deſired a copy, nor had a ſight of them. By this means it happened, that beſides thoſe many titles, which being handled at large in the hiſtory, are left untouched in the following tract, even on thoſe occaſions, where the learned doctor and I happen to treat of the ſame ſubjects, our trials are but very few of them coincident; upon which ſcore the reader will meet with more variety betwixt us, than probably he would have expected to find on ſuch an occaſion.

HAVING drawn up this advertiſement about the doctor's papers, as ſuppoſing them the very ſame he preſented to the Royal Society; upon a ſight of the following ſheets, (as they were ſome hours ſince brought me from the preſs) the additions I there find, make it appear neceſſary to ſay ſomething further to the reader. I muſt inform him then, that about the middle of this winter,

* That learned gentleman Mr. *H. Oldenburg*, ſecretary to the Royal Society.

† This is pointed at in the 2d page of the following account, where mention is made of an honourable perſon, &c.

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winter, and about the end of *December* 1664, I preſented to the Royal Society ſeveral books, containing each of them eighteen or nineteen of the twenty-one titles, whereof my hiſtory conſiſts; that the Virtuoſi might have the opportunity of the cold (which then began to be ſo ſtrong, as to keep the preſs from diſpatching the reſt of the book *) to examine my experiments, and add to them: and one of theſe being delivered to the doctor, as the likelieſt perſon to make uſe of it, together with an order to the ſtationer, to let him have the remaining ſheets of the book, as faſt as they ſhould from time to time be printed; he had the curioſity, as to enlarge ſome of the things he had already tried, and brought in himſelf, (as is intimated in page 389) ſo to make trial of ſome particulars, that I had propoſed and performed, which either their importance, (as the way of freezing from the bottom upwards, by me ſuggeſted, and the weight of bodies frozen and unfrozen) or his opportunity invited him to make choice of; and has been pleaſed to afford them place among his own experiments †; by which means, though the coincidence of what we deliver will appear to happen more frequently, than the advertiſement will make one expect; yet to ſuch readers, as do not prefer variety before certainty, the coincident paſſages will not, in likelihood, be unacceptable. For, in thoſe caſes, where the events of our trials are the ſame, it is like the truth will be the more confirmed ‖; and in caſes where the ſucceſſes are very differing, the reader will be excited to make farther trials himſelf, and will be thereby enabled to judge, which trials have been the moſt carefully made, and the moſt warily delivered. And, though I think it but a neceſſary profeſſion for me, to ſay on this occaſion, that I am pretty confident of my having performed my duty, as to the hiſtorical part; yet this need not hinder, but that moſt of the differing ſucceſſes, we are ſpeaking of, may prove but inſtances of the truth of what I long ſince admoniſhed the Reader (in my preface) that there are among the experiments of cold, divers, that are liable to contingencies; ſo that, as I would not have the papers of this learned man comprehended in what I ſaid of the jejuneneſs of the writers I had met with, who treat of cold, in a preface written, when I was not ſure the following papers would not be made publick; ſo I hope the reception of theſe papers of this ingenious perſon will be ſuch, as may invite him to haſten the publication of thoſe fruits of his learning and induſtry on another ſubject, which divers of the Virtuoſi do not more expect, than deſire, to have communicated to them. *The Art of Pottery.*

A N ACCOUNT of FREEZING,

Made in *December* and *January*, 1662.

SINCE the buſineſs of freezing is obnoxious to many various contingencies, I muſt neceſſarily premiſe theſe following circumſtances. That theſe experiments were made in very hard weather, yet with ſome alternate relaxations, the froſt continuing above ſix weeks. And the place I choſe was in ſtone windows, expoſed to the North, and North-eaſt winds, and ſome upon the ground. The veſſels were glaſs-canes of ſeveral bores; earthen and pewter, ſmall pans and porringers; ſpoons of pewter and ſilver; glaſſes of various figures, as phials, cylindrical, round and ſquare; flaſks, recipients, bolt-heads, and ſome conical ones. Moſt whereof, by the diverſity of their figure, their openneſs or cloſeneſs, produce various effects in freezing, as the following obſervations will ſhew. The quantity alſo of the liquor expoſed is to be conſidered; for what will ſhew a ſmall thin plate of ice in a ſmall parcel of ſome liquors, will ſhew none in a greater.

THE method I ſhall follow in delivering my obſervations ſhall be, firſt, to run over the various liquors or bodies, whether fluid or conſiſtent, ſimple or compound, *&c.* uſed in this work. Secondly, what figures obſervable in thoſe ices. Thirdly, ſome effects ariſing thence. Fourthly, ſome properties and qualities. Fifthly, ſome lets or helps both to freezing and thawing. Sixthly, ſome uſes of ice.

IN purſuance of which particulars, I had recourſe to thoſe ingenious queries of Mr. *Henſhaw*, regiſtered in your *Cimelia*, and then to *Bartholinus*, in his late book *de Nive*, and to my own collected notes from various authors, adding whatſoever trials I thought meet. And in all theſe I have barely ſet down matter of fact, neither mentioning the authors, nor their errors, which would have been both nauſeous and tedious; nor ſhall I endeavour to render a reaſon of the various φαινόμενα, (which cannot be done without a volume) but ſhall leave that province to an honourable perſon of this ſociety, who hath had much experience and reflections on this ſubject. And now to my taſk.

* See the publiſher's advertiſement to the reader.

† Among which I am ſince informed, that he had tried divers, before he ſaw my papers.

‖ So one of the chief paſſages of the Examen of Antiperiſtaſis is much confirmed by page 389, following; which contains an account of a trial made by the command of the Royal Society, to whom it was propoſed by the Author of the Examen, with a requeſt, that they would pleaſe to order it to be made.

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As to my firſt head of things uſed, I ſhall begin with common water, which I expoſed in a triple ſtate, in like quantities, and in open pans, *viz.* firſt, cold; ſecondly, boiling hot; thirdly, an equal mixture of both the former. The effect was this; the cold was frozen in one hour, the boiling hot in two hours, and the mixt in an hour and a half; but with this difference, that the cold did freeze firſt at the top, and ſides, and had a large thick cruſt before there was any ſhew of ice in the boiling hot; but the mixt and boiling hot began to freeze firſt at the bottom of the veſſels, and when the top was cold, then it freezed there alſo, leaving betwixt the bottom and top of the veſſel a cavity for the water, which in time was wholly converted to ice. The ſame ſucceeded moſt manifeſtly on theſe waters poured on a ſmooth table, where the cold water was preſently frozen, before the boiling hot water could become cold at the bottom.

WATER exhauſted of air in Mr. *Boyle*'s engine was frozen almoſt as ſoon as a like quantity expoſed in an open pan; the ice whereof appeared white, and to conſiſt purely of bubbles. The glaſs uſed was a four-ounce round phial, and a ſmall tube one foot long half filled with water.

FAIR water, wherein arſenick had been infuſed eight months, congealed much ſooner than a like quantity of water, into a very white ice.

SOLUTIONS of all the ſorts of vitriols freezed ſooner in pans and tubes, than water, or any ſolution of the other ſalts by much, though that of allum came very little ſhort of it. The ice kept both colour and taſte upon the leaſt touch of the tongue, in all of them.

A SOLUTION of allum did freeze into an ice whiter than milk, and ſtuck ſo cloſe to the ſides of the pan, that it could hardly be ſeparated from it: this was the firmeſt ice offered to me in all my trials; next to which, in both theſe qualities, were the vitriols, eſpecially the Roman.

SANDEVER quickly freezeth, frit ſooner than it, and kelp than them both; all of them into lumps very white, and conſequently not diaphanous.

SAL ARMONIAC ſhewed ſome variety in point of time; for in the ſame pan, quantity, and place with the other ſalted waters, it would, for the moſt part, freeze long after the former, though once it did freeze before them.

COMMON ſalt two drachms diſſolved in four ounces of common water (for that proportion I obſerved in all my ſolutions) did, in 30 hours ſpace, in the hardeſt ſeaſon, turn to pretty hard and white ice; whereas the former ſolutions became ſo in two or three hours at the moſt.

A BEER-GLASS was filled with ſtinking ſea-water full of ſalt, which within 26 hours acquired at the top a plate of ice of the thickneſs of half a crown-piece, with few bubbles in it. This taſted ſalt and ſtinking as before, but being diſſolved at the fire, or thawed of itſelf, the ſtinking taſte was gone, but the ſaltiſh continued. The reſidue in the glaſs within four days (the ſeaſon continuing) and plates taken off (once in twenty-four hours) was frozen throughout, but that at the bottom of the glaſs ſeemed to have a much briſker taſte than that at the top, neither was it ſo firm and friable as that. I tried another beer-glaſs with the ſame water, which froze moſt part of it, but the ſeaſon continued not ſo conſtantly ſharp ſo long together, as in the former experiment, and therefore I could conclude nothing therefrom. But in ſmall broad earthen pans ſet in ice, in 36 hours the ſame water became ice throughout, and with the addition of a parcel of ice or ſnow much ſooner.

SOME water is impregnated with as much bay-ſalt, ſome with as much ſalt-petre, ſome with as much ſal armoniac as the water was capable to receive, and neither of theſe did congeal with the higheſt degree of cold, continued ſix days together.

A SOLUTION of ſalt of tartar ſoon converted into ice, but in much longer time than common water. I obſerved, that it began to freeze in a tube at the top, bottom, and ſides firſt, leaving the liquor in the middle unfrozen; whereas other ſolutions and liquors congealed uniformly, by deſcending, or aſcending, or both at the ſame time, from ſide to ſide through the middle. Of this I made but one trial.

SALT-PETRE required 28 hours in a very cold ſeaſon, and in that time became in the open pan a moſt pure white ice perfectly like ſal prunellæ, which an apothecary miſtook it for. This ice thrown into the fire (after the aqueous humidity was evaporated) did ſparkle as that ſalt uſeth to do. A ſtrong lixivium made hereof with an addition of copperas or allum ſingly, or mixt, ſet in ſnow and ſalt, or ſnow alone, was frozen in one night.

SAL GEM alone of all the ſalts, though ſnow and ice were mixed with it in great proportion, and though the pan was ſet in ſalt and ſnow, could not all that time be brought to congelation; an odd experiment. Phlegm of vitriol did freeze ſooner than the ſolutions before-mentioned.

OIL of vitriol begins congelation (or coagulation rather) near as ſoon as fair water. A pretty large tube was filled $\frac{3}{4}$ full with this oil, and about $\frac{1}{4}$ thereof was frozen, the reſt remaining at the bottom uncongealed. This tube was broken in the preſence, and by the command of this honourable ſociety, the coagulated part whereof was taſted by many then preſent, and concluded by all thoſe, that it was a ſtrong vitriolate taſte. This coagulated part was of a paler colour than the other, and both theſe mixed and poured into a phial-glaſs heated it ſo hot, that none there could hold it. This coagulated part kept ſo in the air a week after all my other liquors had been thawed, and would, in probability, have continued ſo much longer, had not the glaſs been broken. I expoſed another leſſer tube with the ſame oil, which became frozen throughout, and required very much relaxation in the air to return its former fluidity.

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I Had ſet a mark on theſe tubes (as on all the reſt, to obſerve their ſeveral riſings) and the oil of vitriol, when coagulated, ſunk more than half an inch below it, and being diſſolved at the fire, returned to its firſt ſtation, as you alſo ſaw. And this φαινόμενον is peculiar to this oil alone, all other liquors riſing higher than the mark.

I Now come to my ſtronger liquors of beer, ale, and wines.

I Exposed at the ſame time a flaſk of ſmall beer, and another of ſtrong ale; the former whereof was frozen throughout in 38 hours, but three pints of the ale continued unfrozen after ſix days continuance of very hard weather. And the air then diſpoſed to thawing, I broke the flaſk, and with the unfrozen liquor made an excellent morning's draught at four in the morning. This ale in colour, ſtrength and quickneſs ſeemed to me and the other three taſters that ſate up with me, much better than when it was firſt put into the flaſk, and by comparing it with ſome other in the houſe of the ſame barrel, we plainly found the ſaid difference. After this I took the icy part of the ale, and thawed it at a fire, which was in all a pint of liquor (though the flaggon contained three pints of liquor, was filled with the ice) was very pale, and of a quick and aliſh taſte, very much reſembling that drink, which the brewers call *Blue John*. This ice was not ſo firm as that of water, but fuller of bubbles.

I Assayed the ſame a ſecond time, but could not, by reaſon of the changeableneſs of the weather, attain ſo great a thickneſs of ice as in the former. And in this alſo I found the ſame changes as before.

A Beer-glass of *Hull*-ale in twenty-four hours contracted a cruſt of ice as thick as an half-crown, and proceeding, as in ſea-ſalt water, the φαινόμενα were the ſame, all the laminæ taken off appeared of the ſame colour and taſte, and the loweſt ice was the moſt tender. Another glaſs of the ſame ale expoſed did not freeze throughout (no cruſt being taken off) in five days, when my own ale did in a like glaſs, both being ſet out together. Now the taſte and colour appeared the ſame, or at leaſt had no ſenſible difference, when they had been thawed of themſelves, and when firſt expoſed. *Hull*-ale hath a brackiſh taſte.

Claret very ſtrong expoſed in a ſpoon, in 35 hours hard freezing became an ice all of it; it was ſoft, kept its former colour and taſte, ſoon diſcovering to the tongue of one who knew not whence it was, its nature, quality, and kind.

Canary at the ſame time in a ſpoon expoſed, in 38 hours acquired on its ſurface an exceeding thin plate of ice, as thin as the fineſt paper, and proceeded no farther in four days following.

Neither claret nor canary would ſhew the leaſt ſign of congelation in tubes, much leſs in bottles.

Two ounces of the beſt ſpirit of wine expoſed in an earthen pan did all evaporate in leſs than twelve hours, but the ſame quantity of brandy left near a ſpoonful of inſipid ice without any taſte of the ſpirit, which caſt into the fire flamed not at all. I could diſcern no bubbles in this phlegmatick ice, but having interpoſed it betwixt mine eye and a candle, it manifeſted many bubbles by its ſhadows. Query, whether this may not turn to profit in colder countries in rectifying ſpirits of wine?

We now come to confiſtent bodies, and ſhall begin with animals, and their parts.

Two eyes, the one of an ox, the other of a ſheep, in one night were both totally frozen; the three humours were very hard, not ſeparable one from another, neither of them diaphanous, as naturally they are; and the cryſtalline was as white as that of a whiting boiled. The tunicles, fat, and muſcles were alſo frozen, as appeared by their ſtiffneſs, and by putting them into cold water. The ice of the wateriſh and glaſſy humours ſeemed to be made of flakes.

A Pint of ſheep's blood did freeze at the top, and all the ſides of the diſh, wherein it was put, and was nothing elſe but the ſerum of the blood. This ice being ſeparated from the blood, and thawed at the fire, and then again expoſed, congealed into a ſeeming membranous ſubſtance, and was taken for ſuch by ſome that ſaw it, and ſo continued in a warm ſeaſon, and appeared in all reſpects a membrane. This alſo was ſeen and regiſtered in the journal. The blood remaining gave me no ſigns, that froſt had taken it.

I Dissected a dog and a cat, having lain dead in the open air, and found their entrails, nay, the very heart ſtiff, and ſome little ice in the ventricles of their hearts, and their *vena cava*.

Milk ſoon frezeeth into moiſt white flakes of ice, retaining the proper taſte of milk; theſe flakes are ſoft, and manifeſt not many bubbles.

Several eggs were expoſed, and both yolk and white in one night were hard frozen. They require a longer time to freeze than apples do. The beſt way to thaw them both, is to lay them on *Newcaſtle*-coal, or in a deep cellar. Whether eggs once frozen will produce chickens or no, I cannot ſay, but have been told by good houſe-wives they will. Some affirm, that eggs and apples put into water, the ice will be thawed within them, and the ice appear on the ſhell and ſkin. It is true, if you hold either of them near the ſurface of the water, they will ſoon gather a very thick cruſt upon their outſides; but if you then break the one, or cut the other, you ſhall ſee them full of ice, and the eggs then poached will taſte very tough. So that this ice ſeems to be gathered from without, and not come from within. And beſides if it did ſo, they muſt needs loſe their weight, the contrary whereof will anon appear. But for the more ſurety, I proceeded to this farther experiment. I immerſed in my ciſtern an egg, and an apple, two foot deep into water, and there ſuſpended them with ſtrings tied about them, to keep them from ſinking for the ſpace of twenty-four hours, and then took them out, and opened them. I could never obſerve in that time, though I often looked atthem, any ice on their outſides, and

and the one being broken, and the other cut, were found both of them full within of ice.

THE next order ſhall be vegetables, and of them a few inſtances, eſpecially thoſe which are of a biting or ſour taſte. Now for the firſt, I employed the roots of horſe-radiſh and onions, (for other edible roots and plants every one knows will freeze) which ſhewed the froſt had taken them by their taſte, and ice was found betwixt each of the ſkins of the onions, retaining the taſte of the root; yet I have obſerved beer, wherein horſe-radiſh and garden-ſcurvigraſs have been infuſed, will not freeze ſo ſoon as other ſtronger beer without them.

ORANGES and lemons frozen have a tough and hard rind, their icy juices loſe much of their genuine taſte; they were both frozen hard in 26 hours, or a little more, having a thick rind. They, as other fruits, when thawed, ſoon become rotten, and therefore the fruiterers keep them under-ground in low cellars, and cover them with ſtraw, as they do their apples.

WHICH did, expoſed in one night, freeze throughout. If you cut one of them through the middle, it will have on both the plains a moſt pure thin ice, hardly diſcernible by the eye, but eaſily by the touch, or by ſcraping it off with a knife. The cores of theſe apples ſoon turn brown, and begin their corruption there.

OIL expoſed did acquire the conſiſtency of butter melted, and cooled again; but in caves and cellars I could never ſee it more than candy.

STRONG white-wine vinegar did all ſoon freeze in a tube, and without any apparent bubbles.

AND to conclude, without mentioning nuts, bread, butter, cheeſe, ſoap, and many other things, which came under my trial, it is moſt certain, that whatſoever hath any wateriſh humidity in it, is capable of congelation: what are not, you have in the next paragraph.

HAVING now done with what will freeze, I ſhall briefly recount ſome things, whereon the cold hath no ſuch effect.

WE mentioned before ſpirit of wine: add to it ſuch ſtrong waters as are made of it, *viz.* aqua Mariæ, cœleſtis, *&c.* and canary wines in larger veſſels. Secondly, the ſtrong lees of ſoap-boilers, and others made of other ſalts, to which refer the ſpirits extracted from ſalt; vitriol, ſalt-petre, aqua fortis, and ſpirit of ſulphur, which laſt precipitated to the bottom of the tube a ſmall quantity of powder, very like in colour to *ſulphur vivum*, which being ſeparated from the ſpirit (for nothing of that evaporated) cracked between my teeth, and taſted like brimſtone, and being put into water, made it as white as lac ſulphuris doth, but it would not flame, perhaps becauſe too much of its ſtrong acid ſpirit was mixed with it. Spirit of ſoot afforded alſo a precipitation or ſediment (the ſpirit not congealing) at the bottom of the tube of a yellowiſh colour, but much bitterer than the ſpirit itſelf, and inflammable alſo.

BUT here it is to be obſerved, that the ſaid ſpirits, that would not freeze alone, yet with the mixture of about 12 parts of water, or leſs of ice, or ſnow, did freeze throughout; except the ſpirits of ſalt, of nitre, and aqua fortis, which would not freeze with thoſe quantities of water, ice, and ſnow. I intended to have tried them with a greater quantity of the ſaid ingredients, but the weather failed me.

WHETHER the ſalt-water freeze in the ſea, I cannot experimentally determine; but I ſhall add what was told me by one, that ſaid he had diſſolved ice in the northern ſeas, and found it very ſalt.

THE next propoſed was the figure of liquors frozen; wherein I ſhall obſerve in general, that moſt of the liquors differed from one another in their figures, and being permitted to freeze, and thaw often, they ſtill returned to the ſame figure, moſt whereof were branched. Allum appeared in lumps; ſalt-petre, tartar, milk, ale, wine, and ſal armoniac in plates; and other liquors mentioned to freeze into a very ſoft ice, ſeeming to be made up of ſmall globuli adhering each to other. Fair water, kelp, and the frits reſembled an oaken leaf, the leafy parts being taken away, and the fibres only remaining, the interſtitia being filled up with ſmoother ice. The middle rib (if I may ſo ſay) as in plants was much bigger than the lateral ones, all which ſeemed but different ſtiriæ, whoſe points extended towards the outſide of the veſſel containing the water, and made acute angles with the middle rib towards the leſſer end of the ſaid leaf.

CONCERNING the figures of frozen urine I ſhall ſay nothing, the accurate deſcription of curious Mr. *Hook* having ſo fully and truly performed that part of my taſk.

NOW as to the famous experiment of *Quercetan*, and affirmed by many other chymiſts, I made experiments in theſe following vegetables; roſemary, rue, ſcurvigraſs, mints, and plantane, wherein I thus proceeded: I mixed with $\frac{1}{2}$ a pint of their diſtilled waters $\frac{1}{2}$ or $\frac{3}{4}$ of an ounce of their own ſalts; the roſemary and rue were calcined, and their ſalts extracted with their own waters, and then were added to their ſalts their own diſtilled waters in the above mentioned proportions. The glaſſes, wherein the rue and plantane were put, being ſealed with *Hermes*'s ſeal, and the other glaſſes left open, the effect was, that neither of them ſhewed the leaſt reſemblance of the plants, from which they were extracted, neither figure, nor ſhew of roots, ſtalks, branches, nor leaves, (but only a lump or heap of ſmall globuli) much leſs of flower or ſeed. Beſides the kelp frozen hath many fibres, which is made the moſt of it of *alga marina*, whoſe leaf is long and ſmooth without fibres in it. This one thing I cannot pretermit, that the ſcented waters ſeemed upon their thawing to have acquired, and advanced much in their ſcents, and eſpecially the roſemary, whoſe ſalt hath no ſmell, and its water but little; yet thawed, they ſmelt as ſtrong almoſt as freſh leaves rubbed and ſmelt to.

A LARGE recipient was filled with water, which being frozen throughout, and the upper cruſt of the ice broken, there appeared in the middle of it a multitude of thin *laminæ* of ice, ſome

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ſome more, ſome leſs wide, from which proceeded *ſtiriæ*, or teeth pointing inwards, and ſet at pretty equal diſtances, ſo that the *laminæ* and *ſtiriæ* reſembled very much ſo many combs placed in no order, ſome lying directly, others obliquely, none tranſverſly, having intervals betwixt each of them; betwixt ſome of them I could put my finger without breaking the points of the *ſtiriæ:* theſe combs were placed round about a cavity in the middle of the receiver, ſufficient to receive two of my fingers.

In a flaſk filled competently with water, when it was frozen, there appeared throughout the ice infinite ſilver-coloured bubbles, very like unto tailed hail-ſhot of ſeveral ſizes, the largeſt about $\frac{1}{4}$ of an inch long, where thickeſt, of the bigneſs of a great pin's-head, others much leſs in all dimenſions. The points of them all looked outwards, and the bigger part inwards towards the centre, where alſo were the largeſt. For there they would eaſily admit a little pin into all their cavity, without the leaſt reſiſtance. The figures of them were pretty regular; firſt, a ſmall thread, and then a head as big as a ſhot, and thence gradually ended in a point. Some of theſe were ſtreight, moſt a little crooked. There was a cavity in the centre of this ice filled with unfrozen water, from which I could find multitudes of cavities of bubbles, not fully formed. And in the more ſolid parts of the ice cut, you may diſcern them by a black ſpot, where the hole enters into the cavity. All the ſame phænomena appeared in a ſecond trial, but that the bubbles were ſhorter and larger, and not ſo ſharp pointed. The like I alſo obſerved in a conical glaſs ſealed up.

The next thing to be treated of, is the effects of freezing, *viz.* the expanſion of liquors frozen, and conſequently thereunto the breaking of bodies, wherein they are incloſed. All the liquors tried did ſenſibly in glaſs tubes riſe beyond my mark, before the liquors could ſenſibly be diſcerned to freeze, and after roſe ſomewhat higher with freezing. The height of the riſing I ſhall here ſet of a few experiments, inſtead of many made (having troubled your patience too long in the former paragraphs) in ſeveral proceſſes. Vinegar and urine roſe about half an inch, and lees made with ſalts of roſemary, kelp, the frits, about $\frac{1}{4}$ of an inch. Solutions of alum and copperas ſomewhat leſs, and in general the ſaline liquors leſs than water, which roſe a full inch, and ſmall beer in a very narrow tube four inches; but water in the ſmall capillary tubes could not be perceived, either to expand it ſelf, and certainly not to freeze at all. Oil of vitriol alone (as hath been ſaid) ſinks below the mark. Hot water put into a tube firſt ſinketh till it is cold, and then riſeth before it freeze.

Open-mouthed glaſſes, ſuch as beer-glaſſes, *&c.* filled with water up to the brim, when frozen, the ice will manifeſtly riſe above the ſuperficies, and make a ſolid triangle there. But narrow-necked glaſſes more plainly ſhew this riſing. In a flaſk filled with water four inches below the mouth, the ice roſe above the mouth, and hung two inches without it. And once in a bolt-head the ice roſe five inches above the water-mark. And here I ſhall briefly add two things; firſt, that if glaſſes be filled about $\frac{2}{3}$ full, they ſeldom break; but if more, they will for the moſt part break. Secondly, that round-figured or ſpherical glaſſes for the moſt part break in an uniform manner. I filled a bolt-head full to the neck, and ſtopped it at the top, which was twelve inches diſtant from the body, with a piece of melted candle. The ice roſe above three inches in the neck, and the glaſs broke in the thinneſt part of the body; from the point of breaking, as from a pole, the cracks run as ſo many meridians, but unequally diſtant each from other, and conſequently concurred not in an oppoſite pole on the other ſide; beſides there was great difference in the length of thoſe cracks, none whereof went round the glaſs. In a flaſk thus crack'd in many places, the cracks were very irregular in all the places; for ſome of them ran from their centers upwards, others downwards, ſome ſomewhat parallel, but moſt obliquely, and few of them were conſiderably ſtraight. Glaſs-bottles, and eſpecially ſtone-jugs, keep very little, and the laſt no method in their breaking: the ſame alſo befals ſquare glaſſes: woods follow their grain, and metals no order at all.

And now I come to ſome remarks proceeding (as I ſaid) from this expanſion, *viz.* the breaking of the veſſels, or force of freezing, wherein alſo you may take notice of that quality of cold, mentioned by the poet, *penetrabile frigus*, piercing where light comes not.

Two oval boxes, the one of box, the other of maple (both firm woods) containing each above two ounces of water, were filled full, and with ſcrews cloſed very faſt: both theſe boxes were rended from the bottom to the top in one night, with gaps big enough to receive a barley-corn into them: theſe woods ſtretch but little, and therefore break more ſurely, and with larger rents than ſofter woods will do.

Secondly, a pepper-box of latten made of iron, covered with tin, had the neck broken off, and holes made in the top near the neck; and the bottom, where it was ſoldered, was ſo diſſever'd, that water would eaſily run out there.

Leaden pipes laid above ground were broken in many places. One I ſaw twenty yards long broken in ſeven places, and another in my cellar ſix yards long, broken in two places. I ſaw likewiſe in many places of this city leaden pipes, above a foot deep under ground, broken in ſeveral parts.

Cocks of ciſterns, and other braſs cocks, and alſo the barrels in pumps made of braſs or lead, uſually break with the froſt.

I Expoſed a copper box of a pear faſhion, which did bear three ſeveral freezings, by reaſon of the great extenſibility of that metal; but at the fourth eſſay it cracked all along one ſide of it, almoſt to the ſcrew.

Next I tried a cylindrical ſilver ink-horn; but that did bear five trials, and therein I could perceive neither crack, nor dilatation of its ſuperficies. I intended to have tried it in a ſmall bottle, but the weather failed me. I expoſed alſo

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alſo a round ſilver ball of the bigneſs of a large nut; the ſilver became very ſenſibly extended to a larger ſuperficies, but did not ſuffer any ſolution of its continuity.

TOBACCO-PIPES, and all earthen-ware, taking any froſt in their drying, (before they are burnt,) become very brittle, and being put into a ſtrong fire, will certainly break into many pieces. Tiles of houſes, and hard ſtones in buildings, ſcale and break off upon thawing; and thence it is, that the northern ſides of ſtone-buildings firſt decay, and moulder away, as it is moſt manifeſt in antient magnificent ſtructures.

ALABASTER and marble having any chinks in them frequently break with froſt; and the ſtatuaries tell me, they never ſaw any ſolid marble break: as for flints, paving-ſtones, precious ſtones, and ſuch as will receive a poliſh, the bitumens, as amber, kennel-coal, *&c.* I could never ſee any effect on them.

THE next effect ſhall be that of adheſion, concerning which take the following experiments.

A SMOOTH piece of ice was laid on a ſmooth table, and common ſalt thrown upon it; the effect was, that the ice ſtuck ſo firmly to it, that it could not be ſever'd from the table, without breaking the ice into many ſmall pieces: and it will continue in this cloſe coheſion, till the ſalt hath corroded through the ice to the very table, (making many holes in the ice) and hath melted it to the very bottom. But if you lay ſalt firſt upon it, then the ice ſticketh not, but thaweth. Theſe following ſalts applied (as before common ſalt was) cauſe adheſion to the table, but not ſo firm as it, *viz.* kelp, ſandever, ſal Indus, gem. prunellæ, and armoniac, and pot-aſhes, but not alum, or vitriol.

THE next experiment of adheſion was this; I held a nail betwixt my lips in the open air a very little ſpace, which ſtuck ſo firmly to them, that I could not pull it thence without difficulty and pain.

ANOTHER effect is concentration of ſpirits and colours. Concerning the former, you have already as much as I know, eſpecially in the paragraph of freezing beer and ale. Concerning the latter, take theſe following trials. Cochineal was boiled in water to a very high tincture, and frozen; and to twice four ounces of this decoction was added in one glaſs a little ſpoonful of ſpirit of wine, and in another as much ſea ſalt-water: all theſe were frozen throughout, and every part of this ice ſeemed to me of an equal colour, though the edges, as thinner and nearer the light, appeared of a brighter colour (as they do unfrozen) but the glaſſes being broken, ſhewed no diſcernable difference in any of them, neither as to colour nor taſte. The like trials were made with maddes weed and indico, and the ſucceſs was the ſame.

SECONDLY, I expoſed a pint pottinger full of the decoction of ſoot, which (the air relaxing) did only freeze an inch thick: this continued above a week conſiſtent (in a thawing ſeaſon) and very ſolid. Some, that ſaw it, judged it to be brown ſugar-candy, the taſte whereof was near, if not altogether as ſtrong as the uncongealed liquor remaining at the bottom. And in another trial, when the whole was frozen, no concentration was ſeen. But though it was not my hap to find this effect, my trials having been made in phials, ſquare, cylindrical or round, yet Mr. *Hook*, a worthy fellow of this ſociety, happily lighted on it, as you may perceive by his relation, and ſchemes of his glaſſes hereunto annexed.

SOME affirm, as an effect of freezing, an addition of weight made in the bodies frozen; but this affirmation anſwers not my trials. For in four eggs, and four apples fully frozen, I found the weight of them the ſame, when frozen, and thawed, as they had before they were expoſed; each of the eggs and apples being weighed in this triple ſtate both ſeverally and jointly: with the particular weights I ſhall not trouble you. Beſides, that freezing adds no weight, it is apparent in ſealed glaſſes, from whence nothing can expire, and by exact ponderation of them, I could not perceive any the leaſt difference in weight in the ſaid triple ſtate. This I tried ſeveral times with as much exactneſs as poſſibly I could, and ſtill found the ſame event.

ANOTHER property of freezing is to render many bodies more friable and brittle; as moſt woods, as alſo iron and ſteel, as every one knoweth, that hath uſed croſbows in froſty ſeaſons, and ſo likewiſe the bones of animals; and it is commonly obſerved by ſurgeons, that more men break their legs and arms in ſuch ſeaſons, than at any other time of the year, eſpecially ſuch, who have been tainted with the *Lues Venerea*, as *Hildanus* ſomewhere notes.

I SHALL now conclude the effects of freezing, by ranging them into good and bad. The good, are the long preſerving bodies moſt ſubject to putrefaction; healthineſs, and confirming the tone of all animals; and thickening the hairs and furs of ſuch as have them, fatten ſome. Beſides, it exceedingly clears the air, and other bodies, as it is manifeſt by the ſtinking ſea ſalt-water before-mentioned, as alſo by this that follows: namely, I took ſix of the moſt muſty ſtone-bottles I could procure, and competently filled them with water, which, after freezing and thawing again, became as ſweet as ever they were before.

BAD effects, are the killing and deſtroying animals and vegetables by congealing and ſtopping their vital and nouriſhing juices, rendering them totally immoveable. It is obſervable, that in *Greenland*, and *Nova Zembla*, nothing but graſs grows; as alſo what was told me by Dr. *Collins*, the preſent phyſician of the emperor of *Ruſſia*, that no thorny plant or thiſtles grow in that country. And this preſent year moſt of the roſemary and ſage about *London* was wholly deſtroyed, beſides moſt of the more tender plants.

MY fourth propoſal was the properties and qualities of ice, ſome whereof my taſk ingageth me to enumerate only; ſuch as are its ſlipperineſs, ſmoothneſs, hardneſs, whereby, and by its bulk and motion, it breaks down bridges, *&c.*

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its firmneſs and ſtrength to bear carriages, and burdens; its diaphaneity, which is much leſs than the liquor, of which it is made. For I could never diſcern any object, though but confuſedly, a foot beyond the cleareſt piece of ice, by reaſon of the many bubbles and luminous parts within it. Which bubbles ſhew only ſhadows, but the ice itſelf interpoſed betwixt your eye and a candle appears in many round circles, from which proceeded many rays of light, four or five, or more, in the form of a ſtar of about $\frac{1}{4}$ of an inch in diameter, which ſo glaze your eyes, you can ſcarcely ſee any thing but bright light and ſhadow.

As for its penetration and thickneſs ſomething hath been ſaid above; to which I ſhall add, that I have ſeen the *Thames* ice of the thickneſs of eight inches, or more, near the middle of the river, and on the ſides much more. And in garden-walks the earth frozen near two foot deep; whereas on the other ſides of the ſame walks, on a richer mould, the froſt did not reach much above one foot and $\frac{1}{4}$, and pipes of lead have been broken above a foot under the ſurface of the ground. I ſhall not mention the huge mountains of ice found in the moſt northerly ſeas, but proceed to its weight.

It is generally known, that ice ſwims upon the water. But I have ſeen ſnow-balls, moiſtened only with water, and then compreſſed with a ſtrong force, and afterwards frozen, to ſink: beſides, the congealed oil of vitriol deſcends in water, and common ice is frequently obſerved under water; whether the ſolutions of ſalts frozen will ſink, was by me forgotten to obſerve, and whether coagulated oil will ſink in unfrozen, as *Bartholine* affirms. Some affirm, that ſnow-balls hard preſſed, without addition of water, will ſink; but experience teacheth me the contrary.

As for its tactile qualities, every one knows it is colder than water, which you may increaſe by adding ſalt unto it, or rather ſnow.

Smell it hath none, but it binds up that quality in all, but moſt ſpirituous bodies, which it alſo in ſome degrees refracts in them.

Lastly, ice yields both reflection and refraction, whereof I ſhall ſpeak, when I come to its uſes.

My fifth head was letts and helps in freezing, which I ſhall briefly diſpatch. Thoſe beſides the North and North-eaſt winds, the abſence of the ſun, and the higheſt parts of houſes or mountains, are the mixture of ſnow and ſalt (than which there is nothing more painfully and inſufferably cold to my feeling) as is apparent by the trick of freezing with ſnow and ſalt by the fire-ſide; as alſo by the ingenious way of making cups of ice, invented by an incomparable perſon.

Add hereunto, that water falling or thrown upon ice or ſnow ſoon becomes congealed. A mixture alſo of ice beaten into powder, and mixed with common ſea-ſalt (which is beſt) or with kelp, allum, vitriol, or nitre. And here note, that veſſels filled with water, and ſet upon theſe mixtures, begin their freezing at the bottom of the liquor, and conſequently are not ſo ſubject to be broken, as thoſe are, which are not ſet in theſe mixtures, and that the water riſeth higher with, than without them. I find alſo, that oil of vitriol alone, mixed with ſnow or ice, have the ſame effect, though not ſo powerful.

One affirms, that ſalt-petre diſſolved in water, and put into a bolt-head, and long agitated, not only cools the hand exceedingly (which is very true) but alſo converts it to ice, yea, in the very ſummer month, which anſwereth not my trial, though kept a whole hour in that agitation in the hardeſt ſeaſon.

This following experiment alſo I add, propoſed to me.

I Filled a bolt-head, containing a quart of water, and ſet in an iron pan, ſurrounding it on every ſide with ſnow, which covered alſo part of the neck; and then ſet the kettle over the fire, and took now and then the bolt-head from the fire, whilſt the ſnow was thawing, but not the leaſt ſign of freezing appeared in the water put into the bolt-head.

As for the helps of thawing, take this experiment. I ſet in the ſame cellar three pans full of ice, one on *Newcaſtle* coal, a ſecond on ſand, a third on the earthen floor; they thawed in the ſame order they are mentioned, which was thrice repeated, and once that placed on the coal did thaw, when the other continued their ice. Sealed glaſſes ſeem neither to promote or hinder this act of freezing. The ſame ſucceſs I had with eggs and apples in my cellar.

The laſt thing I ſhall ſpeak to, is the uſe of ice. You may therewith make a ſiphon, being faſhioned and applied, as uſually ſiphons are; and this will happen, whether you make it one continued piece of ice, or two contiguous ones; for in both the water will run exceeding faſt, and this ſiphon ſoon empties all the water out.

A ſecond uſe is for refraction, whereof Mr. *Hook* hath given you already a learned demonſtration. And I having formed ſome ice into various figures, like moſt of thoſe mentioned by the dioptrick writers, the φαινόμενα were the very ſame as in the like figured glaſſes; but how *Deſcartes* made dioptrick glaſſes of it, I know not, eſpecially to make uſe of them. And laſtly, you may make a ſpeculum of it, eſpecially if a piece of blacked paper be placed behind it, and if you hold a candle at a convenient diſtance, there will appear very many ſpeculums to your eye, according to the number of the bubbles contained in the ice. But I could not obſerve any heat proceed from ice, though cut in the true figure for burning-glaſſes, and expoſed in naked ice; but frozen in ſpherical glaſſes it will heat a little.

I shall here ſubjoin ſome propoſitions of the learned *Bartholinus*, taken from his book *De Nive*, being near to the former argument, who affirms,

1. That the more ſubtile diſtilled ſpirits gain a clear ſplendor and elegancy from ſnow placed about them.

2. That the rays from ſnow newly fallen glitter, and excel in a kind of ſplendor, where-

with

with the eyes are dazled. ‘ Both theſe are ‘ true, and have but one common cauſe, *viz.* ‘ the multitude of reflections cauſed by the in- ‘ finite globuli, whereof every flake of ſnow ‘ conſiſts.

3. THAT he ſaw cabbage growing in his garden, putrify on that part, which was above the ſnow. ‘ It is certain, that froſt alone, ‘ with or without ſnow, hath this effect on ‘ cabbage, being of the tribe of ſucculent ‘ plants; and I obſerved, that this year 1644, ‘ our great houſe-leek, or American aloes ‘ (uſually hung up in houſes) kept in an up- ‘ per room, was totally deſtroyed by the cold. ‘ And that apples will rot, I have ſaid before, ‘ and houſewives, to prevent the rotting of ‘ onions, commonly hang them up in their ‘ kitchins, or keep them in their ovens, or ‘ ſome cloſe place. And this preſent year ‘ 1662, I ſaw at Mr. *Box*'s the eminent ‘ druggiſt's houſe, abundance of ſquills or ſea- ‘ onions quite rotten: they were laid in an ‘ open, but cloſe garret.

4. WHEN ſnow melts by the ſun's heat, co- pious vapours from the earth clouded the ſun. ‘ He ſhould rather have ſaid, vapours from ‘ the melted ſnow; and 'tis no wonder, that ‘ vapours cloud the ſun.

5. SNOW melts and falls off from ivy. ‘ I ‘ have obſerved all the ſorts of ivies, and ‘ evergreens with us, and ſome biting plants ‘ too, but find in them all the contrary to what ‘ is here aſſerted. Nay, no difference hath ‘ been obſerved even in hoar-froſts, which ‘ fall equally, and continue on all ſorts of ‘ plants.

6. HE excludes not a ſmall portion of earth from ſnow, though pure, which, ſaith he, is manifeſt from diſtillation. ‘ This experiment ‘ I have found true by evaporation, which is ‘ tantamount to diſtillation; and indeed all ‘ melted ſnow leaves an earthy and foul ſettling ‘ behind it.

7. VISCOSITY with ſoftneſs is greater in new than in old ſnow, and therefore it is brought into a maſs. ‘ Viſcoſity in it I un- ‘ derſtand not; its ſoftneſs indeed is manifeſt ‘ too, by the tracks of beaſts, which appear ‘ more fair, the ſnow not riſing on the ſides of ‘ the impreſſion made by their feet (as it doth ‘ in old) but retains their perfect character.

8. WATER-CRESSES and ſcurvigraſs grow under the ſnow in gardens. ‘ I apprehend ‘ not, that any plant whatſoever grows at all in ‘ hard ſeaſons; my meaning is, that no plant ‘ acquires any greater bulk of quantity, but ‘ keeps at a ſtand only; and this countrymen ‘ affirm of graſs and corn, and gardeners of ‘ other plants. It is true many plants will up- ‘ on thawing ſhew a finer verdure, and if warm ‘ weather preſently follow, all vegetables will ‘ thrive exceedingly. For how they ſhould ‘ thus grow, when their nouriſhing liquor is ‘ congealed, and conſequently become im- ‘ moveable, I underſtand not.

9. AIR is included in ſnow; ‘ which this ‘ way of mine to make ſnow fully convinceth. ‘ I took the whites of eggs, and beat them ‘ in the open air with a ſpoon, into a frothy ‘ conſiſtence, as women do to make their ſnow- ‘ poſſets, and then taking a little of this ſub- ‘ ſtance, and laying it on a trenchard, it ſoon ‘ became plain flakes of ſnow, ſo that none, ‘ that ſaw them, could judge otherwiſe. An- ‘ other accidental experiment proves the ſame; ‘ for having put water into a tube, and having ‘ long and ſtrongly agitated it, there aroſe ‘ many bubbles at the top, which ſoon freez- ‘ ing (my agitation ceaſing) became perfect ‘ ſnow. And now having here ſet down the ‘ way of counterfeiting, at leaſt, if not of ‘ making ſnow, I will add, how a pruina or ‘ hoar-froſt alſo may be imitated. I took a ‘ pail filled with warm water, and hung over ‘ it hair, moſs, and a piece of roſemary: now ‘ the atomical vapours riſing from the water, ‘ fixing themſelves on the moſs, hair, and roſe- ‘ mary, became on them a perfect hoar-froſt. ‘ The like is daily ſeen on the beards and hairs ‘ of men and horſes, travelling in cold winter ‘ nights or mornings, proceeding from their ‘ breaths, ſteams of their bodies, or moiſt ‘ atoms of the air. I tried alſo to make hail ‘ with drops of water, but could not hit on it, ‘ for they would never become white. Whence ‘ it is manifeſt, that hail is not drops of rain, ‘ ſuffering glaciation in the falling, as the re- ‘ ceived opinion of philoſophers aſſerts.

10. SNOW abounds with fat. ‘ This I un- ‘ derſtand not.

11. SNOW with ice ſwims on water. ‘ This ‘ is a clear conſequence from the ſeventh aſſer- ‘ tion.

12. SNOW-WATER boils meat ſooner, and makes the fleſh whiter. ‘ I tried this in fleſh ‘ and fiſh, but could find no manifeſt diffe- ‘ rence, either to their ſooner boiling or white- ‘ neſs.

13. SNOW newly fallen hath no taſte, but ly- ing long on the ground, or frozen, ſomewhat bites the tongue. ‘ My taſte was not ſo acute, ‘ as to diſtinguiſh the biting of one from the ‘ other. It is true indeed, that ſnow frozen ‘ doth more affect the tongue with its coldneſs, ‘ than ſnow alone.

14. WORMS are ſometimes found in ſnow. ‘ This neither my own obſervation, nor relation ‘ from others can make out.

15. FROM ſnow, by a peculiar art, a ſalt of wonderful ſtrength is drawn. ‘ He ſaith not ‘ this of his own obſervation, nor teacheth the ‘ way to extract it.

16. AFTER much ſnow plenty of nuts. ‘ This frequently ſuits with the countryman's ‘ obſervation, but many times fails; ſuch years ‘ alſo commonly produces plenty of wheat, ‘ other ſeaſons concurring.

I ſhall here alſo inſert two remarks out of the ſame authors concerning freezing. The one is, that the great duke of *Tuſcany* diſtilled ſpirit from wine, only by putting ſnow upon the alembick, without help of fire. The ſe- cond, that the duke of *Mantua* had a powder, which ſoon congealed water into ice, even in the ſummer.

AND to conclude, take theſe general obſerva- tions made by the command of the Royal So- ciety, with weather-glaſſes framed after the Italian

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Italian mode, and filled in part with tinged ſpirit of wine. Which I ſhall deliver briefly, and in groſs, and not each day's alteration apart. I took then two of the ſaid glaſſes of equal dimenſions, as near as might be, and filled them with the ſame ſpirit of wine; one of them I placed in my ſtudy-window, ſtanding north-weſt, the other in Mr. *Pullyn*'s ware-houſe under St. *Paul*'s church, and choſe there a ſmall receſs or room, which was moſt remote from the entrance, and the warmeſt in the whole ware-houſe. Both the glaſſes were ſettled in their ſtations the 15th of *October* 1662, the ſpirit in both having the altitude of three inches juſt. When the glaſs in my ſtudy was depreſſed by the cold an inch, I went and obſerved that in the ware-houſe to have received no manifeſt change in its ſtation. And at a ſecond viſit the ſpirit was depreſſed $\frac{1}{4}$ of an inch below, when that above ground was depreſſed near two inches. And during the long continuance of all that hard winter, it never deſcended above $\frac{1}{4}$ of an inch, and never was higher there than three inches and $\frac{1}{4}$ in a mild ſeaſon in *April* following, by which time the papers fixed to the glaſs, and whereon were fixed the degrees, were quite rotten, and the characters ſcarcely legible. And at the ſame time, that in my ſtudy was raiſed to four inches $\frac{3}{4}$. By which it appears, that the ſaid ware-houſe was in the coldeſt ſeaſon as warm as in a mild *March*, for at that ſtation the glaſs in my ſtudy ſtood commonly betwixt two inches and 2 and $\frac{1}{2}$. And ſo indeed this place appeared to one, that went into it at the coldeſt ſeaſon. And to this purpoſe I ſeveral times ſent in at night my hardeſt frozen liquors, which were conſtantly thawed in the morning, though it froze exceeding hard above ground.

The glaſs in my ſtudy, after two days hard freezing, was ſunk below my marks into the very ball; ſo that I could make no further obſervations concerning the cold above ground.

From the former obſervations, that popular error is manifeſtly refuted, *viz.* that cellars and ſubterraneous places are hotter in the winter than in the ſummer; which, though they appear ſo to us, becauſe they warm us in the winter, and cool us in the ſummer, yet they are not ſo in themſelves: for it appears by the former experiment, that in the coldeſt ſeaſon the ſpirit was depreſſed to two inches and $\frac{1}{4}$, and roſe in *April* to $3\frac{1}{2}$; and no doubt would have riſen about $\frac{3}{4}$ of an inch higher, had it continued there, till the hotteſt ſeaſon of the year.

One thing more I obſerved, *viz.* that the tinged ſpirit of wine had in this ſubterraneous vault totally loſt its colour, whereas that in my ſtudy (two years after) ſtill retains its former tincture.

Since the printing of the foregoing papers, *viz.* 1664, (there being no froſts in *England* 1663) I made theſe following experiments.

Finding the 3d of *January* the ſeaſon diſpoſed to freezing, I expoſed a pint bottle of claret, and a glaſs cane filled with canary, a ſolution of ſal gem, train oil, and the oil of *fructus muſæ*; and on the fourth of the ſame month, the night being the coldeſt and ſharpeſt that I ever felt, (which all I ſpake with the next day confirmed) the wind then blowing hard at ſouth-weſt, I found in the morning all the liquors frozen, except the ſal gem expoſed in an earthen pan, which ſhewed at the bottom of the diſh ſome ſeemingly cryſtallized ſalt; the oil of the ſame fruit became very friable, and of a milky white colour, but the train-oil only loſt its fluidity, and became of the conſiſtence of ſoft greaſe. And the ſame night a bottle of the Rheniſh wine, called *Back-rag*, and another of luſty white-wine, ſtanding in a room a ſtory high, expoſed to the ſaid wind, had moſt of the wine frozen in them; the ices whereof being taken out, taſted ſomewhat weaker than the wine itſelf. All the ſame things happened the ſixth night of the ſame month. It is to be obſerved, that the pint of claret, and the ſack in the tube, were both frozen throughout theſe two nights, and after their double freezing and thawing, they loſt nothing of their ſpirit, colour, and taſte; nay, the claret being a ſtrong *Burgundy* wine, though it often ſuffered glaciation and thawing for three weeks together, yet in all that time ſuffered no manifeſt alteration, but appeared the ſame to ſenſe, as when it was expoſed, in colour, taſte, and ſtrength.

As to the concentration of coloured liquors; Mr. *Hook* ſhewed me an oval glaſs, having at one end a narrow cane above an inch long, almoſt filled with water, tinged with cochineal, frozen; throughout, the ice round about, towards the ſides of the glaſs, ſhewed wholly colourleſs, but that in the midſt was of an exceeding high dye, but the ice, that was raiſed to the neck of the glaſs, was lightly tinged with a ſcarlet hue. Hereupon having ſome flaſks by me, I put into one a ſtrong decoction of cochineal, and into another a like decoction of ſoot, which being expoſed to the air, and incompaſſed in a veſſel with ſnow and ſalt, they did freeze to the thickneſs of an inch or more; and the air then beginning to relax, I broke the flaſks, and the diſſolved ice yielded a water totally colourleſs. I made alſo an experiment with a very ſtrong decoction of gentian roots, which being expoſed in a four-ounce phial, the ice thereof had a far deeper colour, and bitterer taſte in the middle, and towards the bottom, than towards the outſides of it.

And whereas *Barclay* relates, that King *James* being in *Denmark* to fetch his Queen thence, in the winter ſeaſon had his noſe and ears in danger of gangreening; which being timely perceived by ſome of the King of *Denmark*'s nobility, they cauſed the parts to be rubbed with ſnow, and ſo the danger was avoided: the ſame travellers affirm, that in the northern parts, where men become ſtiff with cold, and almoſt frozen to death, that they rub the frozen parts with ſnow, or elſe caſt the whole body into water, by which means the whole body is cruſted over with ice, as eggs and apples are, as if the freezing atoms did paſs from the body frozen into the water or ſnow; and this way of curing gangreens from cold, *Sennertus* doth preſcribe. To

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make ſome experiment hereof, I expoſed fleſh and fiſh, and found, that by immerſing them into water, they ſoon became more limber and flexible, and more eaſily yielding to the knife, and compaſſed with a cruſt of ice of the thickneſs of about half a crown, manifeſt tokens of their thawing; and being cut, they diſcovered nothing of ice in them. This, for more certainty, I often reiterated, as alſo in eggs and apples, above a dozen times, and never failed of unthawing them by this way. It is to be noted, if you immerſe the fleſh, fiſh, eggs, or apples deep into the water, no ice will appear on their outſides, but only when you hold them near the ſurface of the water.

As to the Perſian experiment mentioned by *Olearius*, of making huge heaps of ice to be preſerved for cooling of their drinks, I obſerved, that by pouring water into an open pan, or into a flaſk gradually, ſome at one time, ſome at another, I could quickly freeze by this way a whole flaſk-full, when near half of a flaſk filled at once, though helped by art, was unfrozen. I obſerved alſo, that the ditches between *Southwark* and *Rotherhith* had acquired an exceeding thickneſs of ice, cauſed by the flowing of the water in them at full tide; for new water being brought in by the tide, was there congealed to the thickneſs of ſome inches every ebbing and flowing. I obſerved alſo the ice on the banks of *Thames* above two yards thick; the inhabitants told me they had ſeen it three or four yards thick, which thus came to paſs: the tide flowing in, and meeting with great flakes of ice, drove them to the banks, and lodged them on the ice there frozen; which flakes uniting there with the former ice, raiſed it to that exceſſive height or thickneſs. Beſides, every one may obſerve in *London* ſtreets, and elſewhere, in channels, where no conſtant current is, that water coming from the houſes ſoon fill the channels with thick ice; for running but a little at a time, it freeezeth almoſt as faſt as it cometh thither. Nay, I have ſeen ice of ſome yards thickneſs in ſuch places, where a ſmall rill or ſtream of water gently falls on the ſide of a hill.

AMONGST thoſe things, that will freeze, mortar and plaiſter of *Paris* were omitted; and thence it is, that plaiſterers and bricklayers play all the winter.

MY Lord *Verulam*, in his Natural Hiſtory, (and ſome from him have affirmed to me) that apples and eggs covered with a wet cloth will not freeze; but I find no difference in thoſe, that are thus covered, and them that are not.

ADD to thoſe, that ſink upon congelation, all oils from animals, and from vegetables, that are extracted by expreſſion or boiling.

ADD to thoſe, that freeze not, water and ſugar boiled to the conſiſtence of a ſyrup, and alſo other ſyrups, none whereof I could ever take notice, or learn by others, that they would freeze. It is true, that water having an equal quantity of ſugar diſſolved in it, will freeze, but with a little more mixed therewith, freezeth not.

TO try the effect of cold upon loadſtones, I expoſed ſeveral of them in the open air, and alſo within rooms, in the moſt ſevere weather, the needle being kept in a very warm place. At other times I expoſed the needle to the cold air, keeping the ſtones warm, at other times both were expoſed; but in none of my experiments could I conclude any thing certain as to their attractive faculty: for the ſphere of their activity was found to be ſometimes greater, and ſometimes leſs, to a conſiderable difference, in ten ſeveral good ſtones imployed for this purpoſe.

I ESSAYED alſo to find out a ſtandard of cold, whereby to fit the tinged ſpirit of wine for the weather-glaſſes, and to that end made uſe of conduit-water, and the diſtilled waters of plantane, poppies, black-cherry, nightſhade, ſcurvigraſs, and horſe-radiſh; all which were firſt placed in the ſame room where a fire was kept, and then removed, and meaſured out into ſpoons in equal quantities, and alſo a drop of them dropped on the ſame bench: but though this was often tried, I could not make any ſure inference from them. Only I obſerved, that the black-cherry-water did for the moſt part freeze firſt, but the other with very great uncertainty. The horſe-radiſh, and ſcurvigraſs-waters, were for the moſt part froze laſt. The beſt way to diſcover the very beginning of freezing of liquors, is to move a pin or needle through the liquors, whereby the ice will be raiſed, and become diſcernible, when the naked eye can diſcover none at all.

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AN

APPENDIX,

CONTAINING SOME

Promiſcuous EXPERIMENTS and OBSERVATIONS

Relating to the Preceding

HISTORY of COLD.

Particulars referable to the II*d title.*

1. THE 26th of *December* in the morning, (being an extraordinary hard froſt) there appeared to be quite frozen in my window near the fire, a phial full of the ſolution of minium, [made in the ſpirit of vinegar,] ſo ſtrong, that part of it was ſhot into ſaccharum Saturni: only at the top of them there was a little (leſs than a quarter of a ſpoonful) that looked yellow, and was not frozen, though, being poured out, it did not freeze like an oil.

2. A SOLUTION of gold, made with ſalts, and ſtanding in the ſame window by the ſolution of minium, was alſo frozen.

3. There was expoſed a pint phial full of the tincture of lignum nephriticum, which being frozen, there appeared no colour in the ice; when the phial was held from the light, as in the liquor before it was frozen.

4. THE often mentioned ingenious gentleman, Mr. *Drummond*, who was lieutenant-general of the Ruſſian army, told me, that he had divers times ſeen brandy frozen in *Ruſſia*, but the ice was not ſo hard as common ice.

5. A FRENCH ſurgeon, that waited upon an extraordinary ambaſſador to *Moſcow*, being inquired of by me about the freezing of ſpirit of wine, anſwered me, he had good ſtore of brandy frozen in the bottles, and that the unfrozen part, which was retired to the middle, was a ſpirit of wine by great odds ſtronger than ordinary brandy.

THE above-mentioned ambaſſador alſo told me, that it was uſual in their country to have wine freeze.

Paſſages taken out of a letter of the Ruſſian Emperor's phyſician to Mr. Boyle.

6. THE 7th of *December*, I put ſome very ſtrong French brandy into a China cup, ſuch as they drink coffee out of, and expoſed it to the air: in three hours time it was turned into a cruſty ice all about the ſides of the cup, as if ſome cold blaſt had forced it abroad.

WATER and ſallad-oil were expoſed, the oil reduced to the firmneſs of tallow, the water not frozen.

Particulars referable to the III*d title.*

1. THE ſpirit of ſal armoniac made with quick-lime, volatile oil of amber, a ſmall quantity of oil of vitriol, ſolution of ſilver in aqua fortis, ſome diluted with rain-water, and a phial full of weak *ſpiritus ſanguinis humani*, was expoſed two nights and a day to the cold. The event was, that the three former liquors appeared not to be at all frozen; the ſolution of ſilver was frozen, and the ſpirit of blood appeared almoſt totally turned into ice, (for ſomething ſeemed to be unfrozen at the bottom, eſpecially near the middle part of it) and the ice roſe up high enough to fill the neck, and thruſt out the cork, which I found lying upon the ice above the neck. (The glaſs was not hereby broken.)

2. UNRECTIFIED oil of turpentine, though being expoſed all night in a ſingle phial, it would not freeze; yet the ſame quantity (which was about two or three ſpoonfuls) being expoſed in an open earthen pottinger, the upper part afforded ice of a pretty thickneſs, and figured almoſt like that of frozen urine.

3. A TRAVELLER, bred to be a phyſician, informed me, that in that part of *Scotland*, where his father now lives, there is a lake, out of which runs a little river, whoſe waters, neither in the one, nor the other, are ever frozen in the midſt of winter (which in thoſe northern parts is wont to be very ſharp) and that lumps of ſnow and ice caſt into that lake do readily diſſolve there; and yet, as he anſwered me, this water doth not differ in taſte from common water, as he divers times obſerved.

4. I WAS told by a colonel, that the ſoldiers this winter making uſe of ſallad-oil to keep their locks from freezing, found they could not diſcharge; but being adviſed to hemp-oil, they froze not: neither will train-oil freeze, as it is told me.

Particulars referable to the VI*th title.*

1. LIeutenant G. *Drummond* told me, that he had often been fiſhing on ponds and lakes, that had been frozen over ſo ſtrongly, that men might march with cannon over the ice; and yet theſe lakes were ſtored with live fiſh, as they found, when they broke the ice in ſeveral places, and drew their nets under the ice from one hole to another. The fiſh being drawn out, and packed up in this ſtate, would continue good for a month, or better, without being either ſalted or dried.

2. AND it was remarkable, that the fiſhes being drawn out of the water found ſo great a difference

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difference between it and the cold air, that preſently after, as ſoon as they had made ſome few leaps up and down, they were in a trice frozen as ſtiff as boards. He told me, that fleſh and fiſh, if when it was frozen, it was thawed by the fire, would be quite ſpoiled, and the fleſh would not only loſe its natural taſte, but would be incredibly hard and tough. But fleſh and fiſh being kept in cold water, would there thaw, and become tender, and ſo grow fit to be dreſſed; yet he obſerved not, that in the thawing they acquired a coat of ice, as I told him I obſerved frozen eggs and apples do in *England*, when thawed in cold water.

3. HE alſo told me, he had frequently ſeen men to have the end of their noſes, and the upper part of their cheeks frozen, even when themſelves were not aware of it, and that they were very careful not to enter into a ſtove, or come near the fire, to relieve themſelves; becauſe if they did, the frozen parts would be apt to mortify, and come off, but they would rub them well with ſnow, by which means they were thawed, though not without ſome trouble, yet without danger.

4. IN *Lapland* they uſe another way to reſtore frozen limbs, *viz.* by making a certain kind of a cheeſe of deers milk, which they toaſt againſt the fire, and anoint the place affected with the *Caws-boby*, and that reſtores the frozen member immediately.

5. I HAD ſome *Cheſhire* cheeſes, of which I deſired the cheeſemonger to chooſe the fatteſt and firmeſt to reſiſt the froſt; but they were all frozen, as alſo a *Cheddar* cheeſe of a hundred pound. I threw one into cold water, and in a quarter of an hour it gathered ice about it, or rather the water extracted the icicles out of it.

6. FISH thaws ſooner and kindlier in cold water, than in the warm ſtove; but thawing in water is not ſo proper to fleſh, which muſt have a time anſwerable to its bulk, or elſe it will never roaſt further than it is thawed, roaſt it never ſo long, and carefully.

7. IT is their cuſtom in *Ruſſia*, eſpecially at *Moſcow*, to thaw their fiſh (before they put it to boil) by letting it lie in cold water, till it hath got a cake of ice about it, which they take off, and then put the fiſh into new cold water, and, when it is covered with ice, take it out again: this they continue to do, till the fiſh will occaſion no more ice, and unleſs this be firſt done, they find it will never be well boiled.

8. AN old ſea-captain told me, that they very often met with large white bears, out of which they had fat enough, when well ordered, to yield a hogſhead of oil.

THE ſame captain told me alſo, that white bears in or about *Greenland*, notwithſtanding the coldneſs of the climate, have an excellent ſcent; and that ſometimes, when the fiſhermen had diſmiſſed the carcaſs of a whale, and left it floating on the waves three or four leagues from the ſhore, from whence it could not be ſeen, theſe animals would ſtand as near the water as they could, and raiſing themſelves on their legs would loudly ſnuff in the air, and with the two paws of their fore-legs, as with fans, drive it as it were againſt their ſnouts; and when they were (as my relator ſuppoſed) ſatisfied whence the odour came, they would caſt themſelves into the ſea, and ſwim directly towards the whale, as my relator and others obſerve, who had the curioſity to row at a diſtance after them, to ſee whether their noſes would ſerve them for guides, when their eyes could not. He ſaw no other bears in thoſe parts but white ones.

9. AN inquiſitive doctor of my acquaintance bought at *Moſcow* a ſmall quantity of *Malaga* ſack, that did as it were drain out at the bottom of a pipe or hogſhead, that had not been tapped, till it was (unawares to the owner) frozen. This liquor was much ſtronger and better than the wine that afforded it, and the fame of its goodneſs making others croud to buy the remaining part of it, they found it, when the veſſel was kept in a warm place, which thawed the ice, to be little elſe than ſtrengthleſs phlegm. The ſame phyſician had likewiſe ſome ſtrong beer frozen, whereof the part that reſiſted the cold (and was taken up near the top of the veſſel) was ſtronger than wine; but the reſt, which had been once ice, was worth little or nothing. And as to theſe and the like glaciations, the ſame doctor told me, that he obſerved not the unfrozen liquor to retire always into the middle of the veſſel, but rather (eſpecially in ſack) to be intermingled with the ice, almoſt (as I gueſs by his deſcription) as honey is diſperſed into an honey-comb.

10. SOME of the men of the old ſea-captain's, that had been in the frigid zone, being on ſhore off *Greenland*, opened a barrel of good beer ſtanding an end, and before they had drank much of it, the wind turning ſuddenly fair, and being haſtened aboard, they left the barrel behind them; and the next year coming again to the ſame place to fiſh for whales, ſome of them went aſhore in a ſhallop, but were by extreme cold, and the interpoſition of ſome ice, kept for a day or two from being able to get to the ſhip; by which accident their proviſion falling ſhort, one of them remembred the barrel left behind, and coming to it, found it ſtanding where they left it, but very hard frozen; whereupon they took a ſpit they had with them, and made a good fire, and therein heating it red-hot, they broached the frozen barrel with it, and when the ſpit had reached almoſt the middle part of it, there came out ſome quarts of a turbid liquor, but ſo ſtrong and heady, that it made moſt of them drunk, and fall aſleep for divers hours: after which, waking, they did for curioſity ſake ſtave the caſk, and found, that about this ſpirituous liquor the wateriſh part of the beer had been hard frozen on every ſide, and the liquor had been altogether incloſed in thick ice. This relation I had from the old captain himſelf, who was imployed in that voyage.

11. THE often mentioned governor of *Smolenſco*, a famous fortreſs between *Ruſſia* and *Poland*, told me, it often happened, that the French, and ſometimes the Spaniſh wines, that are yearly brought from *Archangel* to *Moſcow*,

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Moſcow, are ſo frozen by that time they come thither, that their owners are fain to break the caſk, and cleave the ice with hatchets, and then they tranſport it from place to place in ordinary jars, (ſo hard it is frozen,) and when they mean to reduce it to liquor again, they put it into another caſk, and that caſk into a deep hole made into the ice or ſnow, where it will ſlowly thaw, and be far leſs impaired, than if it had been thawed by the fire-ſide, or in a ſtove.

The Phænomena of an Experiment about Freezing, made by Mr. BOYLE, referable to the VIIth Title.

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WE took a bolt-glaſs, bigger than two turky-eggs, with a ſtem, which we cauſed to be drawn out at a lamp, till it was as ſlender as a gooſe-quill, or thereabouts. This veſſel was filled with water, till the liquor reached to a pretty height in the ſlender part of the ſtem. Then I put it into a mixture of beaten ice and ſalt, in which mixture a cavity had been before made to receive a good part of it. But though upon our putting the glaſs into this cavity, there would at the very top ſeem to be ſome little ſhrinking down of the water, yet that was very ſmall, and ſometimes very ſcarcely, if at all, diſcernable; nor did the water afterwards appear to ſubſide, and exhibit the other phænomena of freezing water mentioned by the excellent Florentine virtuoſi: only when the liquor began below to be turned into ice, the quick aſcent of it was manifeſt enough.

WHEREFORE we afterward cauſed the ſtem of a round bolt-head of clear glaſs, whoſe globous part was about $3\frac{1}{2}$ inches in diameter (taken on the out-ſide with calliper compaſſes) we cauſed, I ſay, this ſtem to be drawn out at the flame of a lamp, till it was at leaſt as ſlender as a raven's quill; and the glaſs being filled with water to a competent height, that the expanſions and dilatations of it might be very manifeſt in ſo very ſlender a pipe, we obſerved the enſuing phænomena.

FIRST, As ſoon as the globous part of the glaſs came to be as it were immerſed in the frigorifick mixture, the water in the ſmall ſtem inſtantly aſcended, ſometimes the length of a barley-corn, and ſometimes leſs, and ſometimes more. And this aſcenſion was ſo haſtily made, that it often begun and ceaſed almoſt in the ſame moment; after which the water began (though more ſlowly) to ſubſide again to its former ſtation, or thereabout, which, with other circumſtances, made it very probable, that as the Florentine virtuoſi ingeniouſly labour to prove, this ſudden change proceeded rather from the conſtriction of the glaſs it ſelf upon the firſt contact of the frigorifick mixture, than upon the ſenſible condenſation of the water, which is not likely to be ſo ſuddenly effected.

SECONDLY, But whereas the newly named philoſophers recite, as a conſtant phænomenon, that after the firſt ſubſidence of the water, and a ſubſequent pauſe for a pretty while, the water will be conſiderably depreſſed once more, before it begins to riſe, we could very rarely indeed and ſcarce ever obſerve ſuch a thing to happen, though I cannot ſuſpect my ſelf to have overſeen it for want of attention. For my expectation of ſuch a ſubſidence of the water, and its not appearing to me the firſt and ſecond time, invited me to repeat the experiment ſeveral times one after another, and to look very attentively upon the water, and the marks carefully ſtuck on the ſide of the glaſs, to obſerve the motion of the liquor. And this ſeemed the rather ſtrange to me, becauſe I had often formerly obſerved in trials purpoſely made on other occaſions, that water in convenient glaſſes would ſuffer ſome degree of condenſation by the action of a frigorifick mixture, before it would begin to diſcover any ice in it. But having reiterated the experiment, till I, and thoſe that aſſiſted me, grew weary, I was fain to abandon it, leaving the proſecution of it to farther trials. For I dare not ſuſpect, that ſo many eminent virtuoſi, as ennoble the Florentine academy, could miſtake, or miſrelate a matter of fact, not once, but frequently, and uniformly taken notice of by them. And beſides that, as I was ſaying, it is conſonant to my own experiments on other occaſions, in one of the glaſſes, wherein I tried this very experiment, I obſerved the ſecond ſubſidence to be conſiderable. So that I cannot but ſuſpect, that the ſo differing events of their trials and mine, as to this phænomenon, may proceed either from ſome peculiarity in the water they employed, or in the qualities of the glaſs, which the veſſels I uſed were made of, or in the length and ſlenderneſs of the ſtem, conſidered together with the groſſneſs of our Engliſh air in ſnowy weather, the preſſure of the air having elſewhere been ſhewn by me to have a great ſtroke in divers condenſations aſcribed to cold: but whether to any of theſe things, or any other, that, which we have related, is to be reduced, future trial muſt determine.

THIRDLY, I obſerved for the moſt part, that after that ſubſidence, that almoſt immediately attends the firſt riſing of the water, there would be for ſome time, more or leſs, a reſting of the ſurface of the water in the ſame place, which continued till the upper part of the water began to aſcend upon the beginning of the glaciation of its lower parts; and the duration of this pauſe or reſt of the water I found to be very uncertain, being at ſome times at leaſt twice or thrice as long as at other times, according as the frigorifick mixture did more or leſs vigorouſly operate upon the neighbouring water.

FOURTHLY, Though if the experiment was

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tried in glaſſes, whoſe ſtems were of an unuſual bigneſs, the aſcenſion of the water in the ſtem upon the glaciation of it in the globous part, was not ſo quick as to be very remarkable; yet when the ſtem was drawn out to ſuch a ſlenderneſs, as was before deſcribed, the water, after having (as I lately noted) reſted a while, would, upon its beginning to freeze beneath, aſcend ſo haſtily in the ſtem, as appeared ſtrange enough, eſpecially at the firſt ſight: ſo that uſually its progreſs upwards was very obvious, and ſometimes made with ſuch celerity, that in one minute of an hour, or much leſs, it would as it were ſhoot up ſeveral inches, and would have probably aſcended much higher within half a minute more, if the ſlender part of the ſtem had been long enough to permit it.

FIFTHLY, But whereas the Florentine academians inform, that there is a conſiderable intumeſcence or riſing of the water, that does immediately precede glaciation, I never could ſatisfy my ſelf, that I obſerved ſuch a phænomenon. But in ſpite of frequently repeated trials (both alone, and before others) and of ſuch a degree of attention as perhaps is not often imployed even in more nice trials, it always appeared to me, that the aſcenſion of the water was at leaſt accompanied, if not rather preceded, by the actual glaciation of ſome parts of the water, that were moſt contiguous to the frigorifick mixture, or expoſed to thoſe portions of that mixture which were the moſt operative. Nor did it ſeem eaſy to me to aſſign any other, or at leaſt, better reaſon of the aſcenſion of the water in the ſlender ſtem, than the expanſion, that is wont to accrue to water, upon its being actually turned to ice. It is true, that in ſlender ſtems the riſing of the water will be manifeſt upon the production of ſo thin and tranſparent films of ice at the bottom, or ſome of the lateral parts of the globe the water is contained in, that it has often deceived even attentive eyes, and would have deceived me too, if the newly intimated conjecture at the reaſon of the intumeſcence of the water had not made me extraordinarily ſuſpicious, and invited me to look upon the glaſs taken out of the frigorific mixture (and then wiped and held againſt the light) in ſo many differing poſtures, that though in ſome of them I could not, yet in others I did diſcover thin portions of ice, which ſometimes I could within a minute or leſs make viſible to others; becauſe this ice upon thawing would not unfrequently emerge to the confines of the globe and ſtem, and there become eaſily enough diſcernible to a heedful eye. And though when I gueſſed, that the water was upon the point of beginning to freeze, I took it out of the frigorifick mixture, to try if it would afterwards freeze, or make the liquor in the ſlender pipe aſcend; yet I never was ſo fortunate, as to obſerve any aſcenſion of the water in the ſtem, but when there was actually ſome particles of ice in the ball, which though I newly took out of the mixture, as ſoon as I could perceive the leaſt beginning of riſing in the ſlender part of the ſtem, yet I regularly found more or leſs ice to have been already actually produced at the bottom or ſides of the globe. The aſcenſion of bubbles about the time of the water's congelation (eſpecially if the glaſs were ſtirred) I do not here ſolemnly take notice of, it being an uſual concomitant of the glaciation of water.

SIXTHLY, It was remarkable, and not unpleaſant in our experiment, that not only if the glaſs were taken out of the mixture, very ſoon after the water began to aſcend in the ſtem, the thaw, by reaſon of the extraordinary thinneſs of the ice, would begin ſo quickly, that within about half a minute, or ſometimes much leſs, the liquor would begin to ſubſide manifeſtly again. But when the water was ſufficiently diſpoſed to congelation, which it uſually was, if the glaſs were put into the frigorifick mixture ſoon enough, after the total diſſolutions of the little portions of ice newly mentioned, it would, upon the contact of the frigorifick mixture, though the globe were but half buried in it, begin to glaciate in a trice: inſomuch that making obſervation by a minute watch, I have had the water ſhoot up in the ſtem within half a minute, ſo as to diſcover ice in it, and within two minutes (from firſt to laſt) to exhibit ice in moſt parts of the cavity of the globe.

Particulars referable to the VIII*th Title.*

1. TWO ſealed weather-glaſſes, one with ſpirit of wine, and cochineal, the other with a blue liquor made with ſpirit of man's blood, copper, and ſpirit of wine, were immerſed in water, and kept there, till the glaſs, that contained the water, began to diſcover ſome ice within it: then, this water being thrown out, theſe thermometers were removed into oil of turpentine, (ſubſtituted for the water of the ſame veſſel) and ſnow and ſalt being applied to the outſide, the oil of turpentine (whoſe freezing in ſuch a quantity and veſſel we were not afraid of) was made as cold as we could. Whereupon the liquor in both the weather-glaſſes manifeſtly and conſiderably ſubſided beneath the former mark, and in one of them (which had the blue liquor) though it were but a ſhort one, the ſubſidence was made half an inch; which ſtill confirms, that the air may impart a higher degree of cold than is neceſſary to make water freeze, and than is always communicated by ice it ſelf.

2. THE eſſential oils, as Spagyriſts call them, that are made of ſpices, and other ſpirituous materials by diſtillation in water, being, by reaſon of ſpirituouſneſs, unapt to freeze; men could not obſerve, what effect a degree of cold capable of coagulating them would produce, in reference to their taking up more or leſs room, when congealed, than when fluid: ſome liquors having been found by experience to be expanded, others to be condenſed, by being made to congeal or to concrete by cold. Wherefore conſidering, that oil of aniſeed, though an eſſential oil, will loſe its fluidity, not only ſooner than hot liquors, but with a far leſs degree of cold than water it ſelf; I thought this would be a fit ſubject to make trial upon, and accordingly

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ingly having put a convenient quantity of this liquor into a round glaſs, about the bigneſs of a middle-ſize orange, furniſhed with a ſuitable ſtem, we put a mark, where the ſurface of the liquor reſted, as about five inches above the ball. Then putting the glaſs into a veſſel of water, made cold by powdered ſal armoniack put to diſſolve in it, we obſerved, that the oil in the ſtem ſubſiding did grow whitiſh, though by inclining the glaſs it was eaſy to diſcern, what part was yet fluid. In a ſhort time after this the oil ſeemed totally coagulated into an opacous and very white body, (almoſt like ſperma ceti) whoſe upper ſurface was near three inches beneath the mark formerly mentioned; ſo that the liquor appeared to have been not inconſiderably condenſed by the operation of the cold. Which further appeared by this, that whereas the oil of aniſeeds, whilſt fluid, would ſwim upon water, this butter-like concretion would ſink in it. And yet when I watched, I could obſerve, that upon the ſlow thawing of this thickned ſubſtance, there emerged from time to time ſeveral bubbles into the already fluid parts, divers of which bubbles might plainly be ſeen in the coagulated matter before their emerſion; juſt before which ſeveral of them exhibited various and vivid colours, and very pleaſant to behold.

Particulars referable to the X*th Title.*

1. A FLAT bolt-head, ſealed up with a ſtem about 17 inches in length above the ſuperficies of the water, being ſet in the frigorifick mixture for eight or nine hours, the water aſcended 15 inches and $\frac{1}{2}$, that I meaſured, and afterwards $\frac{1}{8}$ of $\frac{1}{4}$ of an inch, according to the meaſure of another; after which time neglecting it for one hour or more, while I was at ſupper, it blew off the ſealed end of the glaſs quite round, and broke the bottom of it into many pieces, leaving almoſt all the whole body of the pipe uncracked.

2. WATER freed from air, by ſtanding a good while in the exhauſted receiver, being ſealed up in a round bolt-head, whoſe pipe above the water was five inches or a little more to the ſealed apex, being ſet in a frigorifick mixture, exhibited an ice very prettily ſhaped, and without conſpicuous bubbles; in leſs than two hours the water came to be impelled up four inches and $\frac{5}{8}$, and ſeemed to reach a little above the baſis of the conical and ſealed part; upon its breaking with a noiſe, the pipe was entire, and there appeared a good part of the water unfrozen under the ice, and the broken veſſel ſeemed to ſmoke. Upon conſidering the ſhortneſs of the conical part of the glaſs, we gueſſed the air to have been compreſſed to about the 20th part of its former room.

3. THE globulous part of a glaſs-egg of about three inches (for it wanted $\frac{1}{10}$th) in diameter on the out-ſide, was filled with water to the bottom of the ſtem, and then being carefully freed and ſealed, was frozen from the bottom upwards, to try, whether the abſence of the formerly incumbent air would not make the ice afford larger bubbles, and conſequently take up more room, than otherwiſe it would, when the water was frozen in the ball; and a little way in the lower part of the ſtem we found, that (the remaining) water reached from the firſt ſtation of the water about eight inches and $\frac{1}{2}$, the length of the whole ſtem being a very little more than ten inches and $\frac{1}{2}$. Being afterwards ſealed up with air in it, and frozen, the ice reached not in it full four inches above the firſt ſtation, though (if I miſtake not) it was as well frozen this time as the former.

Particulars referable to the XI*th Title.*

1. THERE was taken a ſtrong cylinder of braſs, whoſe cavity was two inches in diameter, into which was put a bladder of a convenient ſize, with a quantity of water in it, that the neck of the bladder (which I had taken care to have oiled) being ſtrongly tied, the water might not get out into the cavity of the cylinder, nor be capable of expanding it ſelf any other way than upwards. Then into this cylinder was fitted a plug of wood turned on purpoſe, which was ſomewhat leſs in diameter than the cylindrical cavity, that it might riſe and fall eaſily in it. Upon the upper part of this plug was laid a conveniently ſhaped flat body, upon which were placed divers weights to depreſs the plug, and hinder its being lifted up by the expanſion wont to be made in water that is made to freeze: then a frigorifick mixture being afterwards applied to the cylinder, it appeared within half an hour, or ſomewhat more, by a circle, that had been purpoſely traced on that ſide of the plug, where it was almoſt contiguous to the orifice of the cylinder, that the water in the bladder began to expand it ſelf; and about two hours after having occaſion to ſhew the experiment to ſome inquiſitive perſons, the circle appeared to have been heaved up, in my eſtimate about $\frac{3}{8}$, if not half an inch, notwithſtanding all the weights, that indeavoured to hinder the aſcenſion, though theſe weights amounted to 115 pound; which were all the determinate weights we could then procure, beſides brick, and ſome other things, that were eſtimated at five pounds more. Nor did I doubt, that a far greater load would not have hindered its expanſion.

THE day after the above mentioned experiment was made, to try the expanſive force of freezing water, the ſame was reiterated after the manner above delivered, but with this difference, that having procured more weights, when the plug was lifted up $\frac{2}{8}$ of an inch, or ſomewhat better, (which plug began ſenſibly to riſe within half, or three quarters of an hour, after the frigorifick mixture was applied,) it was loaded with a weight of two hundred pounds, and a fifteen pound piece of lead, and other bodies, as boards, *&c.* to lay the weights upon; which being alſo weighed by themſelves, came to fifteen pounds more, ſo that the whole amounted to 230 pounds: and if the hundred pounds were both of them (as their bulk and weight invited us to gueſs) of that ſort of weights, which are called the great, a hundred containing a hundred and twelve pounds apiece, twenty four pounds muſt be added to the ſum, which would thereby be made up 254 pounds.

2. AN

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2. AN iron barrel, being about 14 inches long, and having about $\frac{3}{8}$ of an inch diameter at the bore, and where the greateſt thickneſs of the metal was $\frac{3}{16}$, and the leaſt $\frac{2}{16}$, or ſomewhat better, being exactly ſtopped at the breech, and having a ſcrew of a convenient length to ſtop it at the other end, was filled with water, and then the ſcrew being put in, the barrel was buried in a mixture of beaten ice and ſalt for about two hours or longer; at the end of which time being taken out, it appeared to have a crack running ſomewhat oblique, by beginning at a place about three inches diſtant from the breech, and reaching to ſomewhat above ſix inches from the ſame: the crack was much more wide and gaping towards the middle of the barrel, which appeared alſo diſtended about that part; the ice being taken out in divers pieces, and held againſt a candle, ſeemed to have ſmaller bubbles than it would have had, if the water had not been pent up. But the minute bubbles were ſo numerous, that they made the ice more than ordinarily opacous.

3. A STRONG barrel of a gun of twenty four inches long, having the touch-hole ſtopt, and a plug of iron, that was fitted to the muzzel, forcibly driven in, after the barrel had been filled with water, was put into a mixture of ice and ſalt, where within about three minutes by my watch, the lately named plug was with noiſe driven out of the end it had cloſed before; and when the ſame plug was afterward ſo driven in, that, to make the cloſure more perfect, the ſides of the orifice of the barrel were hammered down upon the outward end of the plug, yet, within about three minutes more, the frigorifick mixture making the water expand it ſelf, made it again drive out the plug, and that not only with noiſe, but with ſuch violence, that we found it had broken a deal-board, that made the neareſt part of an oblong box, (wherein the operation was performed.) Afterwards the iron plug, being by the help of the fire and a hammer as it were incorporated into the barrel, the touch-hole came to be unſtopped; and though a long iron nail was ſtrongly driven into it, yet the plug being uncapable to be driven out (as before,) the frigorifick mixture being again applied to the barrel, quickly drove out the nail; which, laſtly, being again forced in, and the commiſſure being for farther ſecurity brazed over, there was now no room left for the included water to expand it ſelf much, but by breaking the barrel. But being my ſelf called away, ſo that I could not ſtay to ſee the iſſue of the experiment, I left one to proſecute it, who ſoon after brought me an account, that within about a quarter of an hour (by his gueſs) after the barrel was put into the frigorifick mixture, though of that there was ſcarce left enough to cover it, it burſt with a noiſe, and blew up the cover of the box (wherein the experiment was made) and the crack, which was two inches and a half long, was wide and gaping enough to let me ſee, that the barrel was of a very conſiderable thickneſs at the place, where it was broken.

A NEW pewter bottle, holding (by gueſs) about a pint, was filled with water, and then the top being ſcrewed on; was put into a frigorifick mixture, wherein when it had lain (by our eſtimate) about $\frac{1}{4}$ of an hour, it was broken, not without noiſe; and being taken out, we found in it a crack almoſt an inch and a half long, and in one place ſo broad as to amount to about $\frac{1}{8}$ of an inch. The bottle ſeemed to be every way diſtended, and particularly at the bottom, which was ſo ſwelled, that the bottle would not ſtand upright upon it.

One particular referable to the XIII*th Title.*

THE old ſea-captain told me, that out at ſea, when the wind blew off from the great banks and tracts of ice, they could, by the extraordinary highneſs of the cold, (which would ſometimes make the ſkin of their faces peel off) perceive, which way the ice lay, not only long before they could ſee it, but ſometimes when they were fain to ſail twenty leagues, before they could come to it.

Particulars referable to the XV*th Title.*

1. THREE decoctions, one of ſage, another of roſemary, and the third of parſley, were expoſed in three ſmall earthen pipkins to freeze, and were totally turned into ice, without any uncongealed liquor (that I could perceive) in the midſt: nor did there appear in the ice any reſemblance of the decocted plants, but the ice afforded by the decoction of ſage had a very uneven ſuperficies, and far more rugged than the two other portions of ice, which were neither of them ſmooth; and theſe (eſpecially that of the ſage) were obſerved manifeſtly to be leſs hard or ſolid than common ice.

2. NEWLY expreſſed juice of lemmons being ſet to freeze in a wide-mouth-glaſs, afforded an ice very oddly figured, eſpecially in one part, where it finely repreſented trees, as they are in winter, without leaves.

3. HARD ice groſly beaten, having a great proportion of white table-ſalt put to it, and mingled with it, there aroſe from the mixture great ſtore of whitiſh fumes, as thick (at leaſt) as common ſmoke, which fumes played up and down all the mixture, and laſted a very conſiderable while; and all this, though the weather was very warm, and the experiment made in a room, where there was a very good fire.

4. SNOW-water being put to freeze in ice and ſalt, afforded an ice prettily figured, and had the bubbles produced in it ſo minute, that they hindered not the globe, which the ice conſtituted, from being more tranſparent, than would have been eaſily expected.

5. WE took a quantity (not inconſiderable) of ice, about two pound or more, and having partly reduced it into ſmall lumps, and partly beaten it into ſmall powder, we mixt with it a convenient proportion of bay-ſalt not powdered. This mixture, when it was ſuffered to lie ſtill for a pretty while, did not appear to emit any thing from the ſuperficial parts; but yet afterwards, when it came to be ſtirred here or there, there would in that part ariſe a ſmoke

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eaſy enough to be diſcerned, if the baſon or platter, that contained the mixture, were held between the eye and the light. But if the whole body were ſtirred, then there would be excited ſo viſible a ſmoke, as that it would not only overſpread the ſurface of the veſſel like a miſt, but would overflow it on all ſides for a good while. I uſe the word, *overflow*, becauſe indeed the fumes did not only ſome of them aſcend a pretty way into the air like ſmoke, but the greateſt part of them by far, as ſoon as they were riſen above the brims of the veſſel, did fall down in ſtreams, as if it had been a liquor poured out of a baſon: ſo that the fumes ſeemed ponderous, almoſt like thoſe, that one may obſerve, if he dip a piece of linnen in aqua fortis, and hang it up to dry; in which caſe the emitted ſteams will rather fall than riſe. We alſo took notice, that thoſe ſteams of our frigorifick mixture were far more plentiful than they ſeemed to be; for beſides thoſe, that were manifeſtly ſpilt out of the brims of the veſſel, it was eaſy, by looking upon the mixture in a certain poſition in reſpect of the light; it was eaſy, I ſay, to perceive, that the whole cavity of the veſſel, which was pretty deep, was all covered with thoſe fumes, that played upon it like the thick miſt upon a pond, not being able to paſs over the brims of the baſon. And this aſcenſion of fumes, upon the ſtirring to and fro of the mixture, laſted a conſiderable while, and probably would have laſted longer, if partly wearineſs, and partly buſineſs, had not called me away.

I forgot to note, that, when thoſe ſteams came out the moſt plentifully, I applied my face to them, to obſerve, if I could feel them ſenſibly colder than the neighbouring air; but by reaſon of an impediment, I could not continue in a fit poſture long enough to be ſure, whether thoſe effluvia would in due time feel ſenſibly cold or no. And though I applied a ſealed weather-glaſs to the ſame fumes, and the tincted ſpirit ſeemed thereupon a little to ſubſide, yet ſome circumſtances make me ἐπέχειν till further trial.

6. The old ſea-captain, that ſailed ſo often into the frigid zone, anſwered me, that when his ſhip was immured with ice, ſo that they could not in a long time get ſo much as a barrel of ſalt water, he made wells of the thick pieces of ice, to receive the liquor of the thawed ice, and found that water (though on the main ſea) to be good freſh water, potable, and fit for dreſſing of their meat, and other uſes, ſo that he never feared want of freſh water in thoſe ſeas.

He alſo told me, that he had divers times faſtened the ſhip to the pieces of ice, that reached under water to about 30 fathom, and that once he lay a good while by a piece of ice ſo thick, that it was on ground at fifty fathom, which he clearly perceived, both by ſounding, and other ways of obſerving, that he acquainted me with. Theſe deep pieces of ice (he ſaid) were not very high above the water, inſomuch that when I told him I had found by trial, that a cylinder of our *Engliſh* ice could have but about the tenth part of it above the water it was made of, and made to float in, he anſwered, that that proportion agreed well enough with his obſervation; and added, that the great depth of the ice proceeded from the ſucceſsful ſnows, which, falling from the ſurface of it, depreſs it, and often within two or three days would itſelf melt, ſo as to ſhrink into a third or fourth part of its former thickneſs, and become hard ice. He likewiſe told me, that he had ſailed to 82 degrees and a half of latitude, and anſwered me, that he was not miſtaken in obſerving it, having had very good opportunity to do it by more than ordinary fit inſtruments, that he had carried along with him.

He told me too, that in ſome parts near the coaſt of *Greenland*, he found the variation of the compaſs to be 22 degrees, and not very long after to be ſcarce any at all; which ſtrange alteration he knew not what to make of.

He told me moreover, that the laſt year ſailing in the height of 77 degrees in the main ſea, he was ſuddenly ſurrounded, and his ſhip locked faſt up, only that it was driven by and with the ice, till the 7th of *June* following; and then, the ice opening a little, he made a ſhift to ſteer through it, and purſue his voyage; adding, that he obſerved, that that vaſt tract of ice being once broken, the fragments of it drove towards *Hudſon*'s *Streights*.

7. The old ſea-captain told me as ſtrange a thing, which he had often, though not carefully obſerved, that great tracts of ice dead the wind; inſomuch, that when he has been driven towards the ice by ſtormy weather, and feared to be in great danger, when they came near it, he unexpectedly found a kind of calm, that raiſed his wonder, and freed him from his fear. And at other times going out of the ice upon an almoſt ſmooth ſea, when he had not yet gone far on it, he found, that there was a ſtorm at diſtance from the ice: and mentioning this, as a very odd thing, to a *Dutch* navigator, who frequented thoſe ſeas for the whale-fiſhing, he aſſured him, that he had ſeveral times obſerved this wonderful property of the ice.

One particular referable to the XVII*th Title.*

IN *Siberia* (a northern province of *Ruſſia*) the earth is thawed in ſummer but about two foot in depth, beneath which it continues frozen, and yet over this frozen part of the ground there groweth good corn. This I had from the *Ruſſian* emperor's chief phyſician.

Particulars referable to the XVIII*th Title.*

1. THE little ſealed weather-glaſs being taken, was put into a glaſs broader at the top than the bottom, and greaſed on the inſide with tallow, in which glaſs the ball in the inſide of it was more than covered with water; and that water being frozen, notice was taken whereabouts the tincted ſpirit of wine reſted in the ſtem: after which, the ice being newly taken off from the ball in the open air of an exceeding frofty morning, juſt upon the removal of the ice the liquor roſe a little in the ſhank, as it uſeth to happen, when a glaſs-bubble filled with warm water is ſuddenly removed into cold: but preſently after the tincted liquor, as I expected, ſubſided, not only as much as it had riſen, but a pretty way (the ſhortneſs of

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the inſtrument conſidered) below the former mark. Which may confirm our obſervation, that the free air may communicate a more intenſe degree of cold than ice itſelf.

2. THE weather having continued for ſome time very cold, we placed two or three days ago a truſty ſealed thermoſcope (that was made by the ſtandard weather-glaſs at *Greſham* college, which I therefore call the ſtandard thermoſcope, having uſed it for ſome years) in a cellar, where we had obſerved beer not to freeze in a very extraordinary ſharp winter; and having looked upon it laſt night, which was, as the night preceding, very froſty, the wind being at eaſt, we found, after ten a clock, that the tincted ſpirit of wine ſtood at two diviſions, and at $\frac{1}{8}$ above the freezing mark; and this morning being a hard froſt, it was found to ſtand much at the ſame height. Wherefore having cauſed it to be removed into the free air in the garden, it now being about nine of the clock, is fallen to the freezing mark, and conſequently is ſubſided above two full diviſions or inches beneath its ſtation in the warm cellar. But nevertheleſs I hence obſerve, that the air in the cellar, notwithſtanding the cold weather, is not (or is but very little) warmer than the air in my bed-chamber is wont to be in froſty weather: for the ſame weather-glaſs being uſually kept in that chamber, the ſpirit of wine was wont to ſtand about two inches above the cipher or freezing-mark, in the morning before the fire was made, in caſe there was a moderate froſt abroad; and in ſummer-time, when the weather was very hot, the tincted ſpirit has aſcended to the eighth, ninth, and ſometimes almoſt to the tenth mark.

3. THE laſt night being made extraordinary cold by froſt, ſnow and wind, the ſtandard weather-glaſs (before mentioned) was removed into the garden, and left there till this morning, when the tincted ſpirit appeared to be ſubſided above two diviſions beneath the cipher or freezing-mark; ſo much greater was the cold of the air, than was abſolutely neceſſary for the congelation of water. And yet the coldneſs of this very night did not by Ἀντιπερίστασις ſo increaſe the heat of the cellar, but that a phial, containing about two or three ounces of chymical oil of aniſe-ſeeds, being left there till nine of the clock this morning, was taken out without being thawed into a liquor: which argues, that the heat of the cellar was inferiour to that of the outward air in moderate ſeaſons, ſince oftentimes, both in ſpring and autumn, oil of aniſe-ſeeds is by the warmth of the air kept in a fluid form: as this particular parcel of oil in the ſame phial, wherein it was expoſed, was kept by the moderate warmth of my chamber many times this winter.

4. THIS morning (being *December* 29, 1665) a little before ten of the clock, the weather having been froſty (bating one mild, but rainy day) for near a fortnight, I took my ſealed weather-glaſs out of my chamber-window, and having held it a while in the open air in the court, as alſo wetted it with water, to reduce it the ſooner to the coldneſs of the ambient air, I cauſed one to pump ſo long, till to a younger eye than mine, the water, that came out of the pump, ſeemed to begin to reek; and then I held the ball of the weather-glaſs for a pretty while in the ſtream, that came out of the pump, and obſerved, that it made the tincted liquor conſiderably riſe; and the more, the longer I kept it, till it was riſen to the height of the croſs, which I made in the frame. Then carrying it up to my chamber, though there was a good fire there, the ſpirit of wine began to ſubſide again; thereby ſhewing, that the air in my chamber was colder than the reeking water, that had been pumped out.

5. ANOTHER time (being *Feb.* 17, 166$\frac{5}{6}$) after it had continued froſty weather three or four days, (if I miſtake not the number) about nine or ten of the clock in the morning, I cauſed the water of a conſiderably deep well to be pumped for a good while upon it, after it had been kept a pretty while in the air, to bring it to the temper of that; the pump-water raiſed it by degrees, but ſlowly enough, to between four or five eighths of an inch higher than the pump-water at *Oxford* had been able to do. Then I carried the weather-glaſs to a ſpring, that was wont to ſmoke in froſty weather, and was not far from the pump; and having laid down the weather-glaſs, (that my hand might have no operation upon it) ſo as the ball was covered with water juſt at the ſpring-head; after it had reſted there a good while, I found the tincted ſpirit but very little raiſed: ſo that in all it ſcarce exceeded five eighths above the height it had been brought to at *Oxford*.

AFTERWARDS in the ſame place I brought the weather-glaſs about noon to the north ſide of the houſe, to which the pump belongs; and letting it reſt againſt the wall in the open air for half an hour or more, I found, that though it had been that morning a ſmall froſt, and though the ſun did not ſhine out, yet by the weather-glaſs the air was juſt at the ſame degree of warmth (if not a little greater) that the water had been at the ſpring-head in froſty weather, when there was ſnow upon the ground; and conſequently the air was then much hotter than the water had been in the pump at *Oxford*, where yet in very cold weather it uſes to ſmoke.

Feb. 19, being the third day of the continuance of a moderate froſt, I held the ſealed weather-glaſs under the pump, and having cauſed the water to be pumped for a good while upon the ball of it, I found the tincted ſpirit riſe as high with the warmth of the water, as it had done many weeks before in the depth of winter, by the warmth of the water of the ſame pump.

THE next day, being the fourth day of the froſt, the neighbouring ſpring, which (as I was informed by thoſe I ſent to ſee) had not, during the precedent days, ſmoked, did ſmoke this morning, as one I ſent to ſee, informed me, that another ſpring likewiſe did. About noon (the weather being fair, and the ſun ſhining) I employed one to keep the ball of the weather-glaſs for a competent time covered with water juſt at the head of the ſpring, which had ſmoked in the morning; and by his relation, which was confirmed by the height of the tincted

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tincted liquor, when I ſaw it, it appeared to have riſen higher now by near or a full quarter of an inch, than I could make it do at the ſame ſpring-head divers weeks ago. But note, that this day the ſpring-water was a pretty deal warmer than the air, notwithſtanding the time and clearneſs of the day, as appeared by the ſubſiding of the tincted ſpirit, when brought from the ſpring to my chamber in a froſty morning, the ground being then covered (but not thickly) with ſnow.

6. HAVING inquired of an ingenious man, obliged to make ſome trials about cold, whether he had obſerved any thing to confirm or contradict the ſuſpicion I publiſhed in the Hiſtory of Cold about the coldneſs and temperature of the air; he gave me ſuch an anſwer, that does notably confirm my conjecture. For he told me, that he had divers times obſerved in an exactly ſealed weather-glaſs, that the tinged ſpirit of wine was higher at ſome times, when the weather was froſty, than at ſome other times, when it was not; and that having had occaſion to keep his weather-glaſs with the ball in water, which was afterwards frozen, and continued ice for divers days, he warily brake the ice all about the ball, and removing it thence into the air, though it were in the ſame room, yet he found the liquor to deſcend from ſuch a mark to ſuch a mark; and having deſired to ſee the inſtruments, I found the bigneſs of the ball to be like that of a middle-ſized or ſomewhat large crab, and the ſtem to be about two foot and a half long: and having had the curioſity to meaſure the diſtance between the above mentioned marks, I found, that the liquor, by being removed out of the ice into the air, had ſubſided a pretty deal above three inches.

A relation given me by an ingenious gentleman, lately returned out of Poland.

7. ABOUT the 21, 22, and 23d of *December* 1669, old ſtyle, lying within three *Poliſh* miles of *Warſaw*, we ſaw every day the ſun accompanied with two parhelions, the one eaſtward, the other weſtward, almoſt in a direct line, and diſtant about 8 or 10 times the diameter of the ſun from it, and continued viſible from near ten to twelve a clock, the weather being extreme cold, the air as clear, as poſſibly to be imagined, both night and day; and when the ſun did ſhine, appeared as full of glittering ſpangles or particles of ice. The like hath been ſince, when it hath frozen very hard; which generally happens, the air being very clear, and as generally thaws, the heavens being clouded any time together.

8. THE old ſea-captain, that ſailed ſo often to *Greenland* to fiſh for whales, aſſured me yeſterday, being *April* 8, 75. that 18 or 19 years ago, he ſailed thither in the company of two *Dutch* ſhips, whereof one was a *Hollander*, but the other of *Embden*: the names of the maſters he told me. When they were come together as far as the place, where the *Engliſh* uſed to ſtay in *Greenland* (as I remember) the maſters of the two ſhips deſired this captain to give them leave to fiſh there with him; which, he told them, he could not poſſibly do, being a ſervant of the *Greenland* company, and employed there by them. Whereupon theſe maſters told him, that they would then go ſeek their fortunes in an unknown world; and ſeven or eight weeks after, they came back to him, miſerably diſtreſſed for want of freſh water and fewel, which they deſired his leave to take upon the place; which being but an act of humanity, and intrenched not upon the rights of the company, he willingly permitted. Whereupon they fell into diſcourſe of their voyage; one of the maſters told him, that coaſting along the ice, in hopes to find ſome new land, and ſome place where they might freely, as well as conveniently fiſh for whales, they had at length come ſo far, that after the foggy and dark weather was cleared up, they took the latitude, and found it to be 89 degrees, ſo that they were within one degree of the pole.

THE old captain doubting of this, the maſter brought him his journal, where the courſe was ſet down, which teſtified the ſame thing; and afterwards conferring with the maſter of the other ſhip, (for they ſailed in company) he agreed in the ſame relation. And the captain hearing, that the ſteerſman of one of the ſhips was a *Scotſman*, he got to diſcourſe with him, and ſaw his journal too, which agreed with what the others had declared. And afterwards one of the maſters having occaſion to come to *London*, and being there met accidentally by our captain, he brought him to ſome of the Northern company, to whom he averred the foregoing relation, of whoſe truth the captain ſeemed to me to be convinced. I asked him ſeveral queſtions relating to this odd ſtory, to divers of which he could make no anſwer, having not asked them of his *Dutchmen*; but to ſome few things he gave anſwers, the ſubſtance whereof was, that though there were vaſt regions of ice towards the ſhores, yet where they found themſelves ſo near the pole, the ſea was very open and free; ſo that if wood and water had not begun to fail them, and if they had not feared their other proviſions would not hold out, they might have made a paſſage perhaps as far as *Japan*. That from the north-eaſt there came a great rolling ſea, which one of the maſters, that had been at the bay of *Biſcay*, compared to that *Spaniſh* ſea; and that the cold there was not extreme, but ſuch as they could well endure, and complained no more of, than they did in *Greenland*. That ſailing from *Greenland* towards the pole, they found the compaſs to vary a point, after they had ſailed ſome degrees northward; then the variation of it was for a great while inconſiderable, and a while after that, it came to be two points. And laſtly, when they came to be ſo near the pole, the declination increaſed ſtrangely; ſo that at 89 degrees of latitude they found the variation to be four, not degrees, but points of the compaſs, and that towards the eaſt.

9. THE old ſea-captain told me, that they are in the ſeas frequently peſtered with thick fogs extremely cold, which laſt ſome of them 10 or 12 hours, ſome a whole day, and others two or three days.

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HE told me, that lying at anchor in *Bell-Sound* on the coaſt of *Greenland*, near a mountainous rock, that was very high, he and ſome others made a ſhift to get up to the top, which he judged to have half a mile of perpendicular height; and when they came to the upper part of the mountains, they found the weather very clear, and the ſky very ſerene; and it being then *June*, the ſun ſhined ſo hot upon them, that he and others ſtripped themſelves, and aired their ſhirts and naked bodies to cool themſelves, ſeeing all the while a thick fog like clouds at the bottom of the hill; whither when they came down with ſtore of fowl, that they had killed, they found the fog, as they left it, very dark, and exceeding cold.

A paſſage taken out of the Czar's *doctor's letter.*

10. *Aug.* 29, 1664. This winter we ſtayed at *Vologda* three months, which is north-eaſt from *Moſcow* ſome degrees. I expected the intenſe cold, which is uſually felt there; but (as it happened) we had not three days of that, which we call winter-weather there, notwithſtanding we were there in *December*, in which month it rained unuſual and dangerous. The cold, which is ſo much talked of in books, hath been rare in theſe late years; for ſome *Engliſh*, which have lived there thirty years ſince, have obſerved ſuch an alteration in the climate, that, except I had good confidence in the fidelity of their relations, being men of known worth and ſobriety, I ſhould not adventure to tell you, that in theſe thirty years the winters are become ſo mild, as the notable cold weather, which uſes to freeze people in their way coming to market in ſeveral poſtures, as they were ſtriking their horſes, or guiding their ſledges, hath been rarely felt, only to the freezing the noſes and cheeks of ſome people, which may rather be termed a blaſt, than a ſettled intenſe cold.

11. THE warmer the room is made by day, the thicker is the hoar upon the glaſs at night, ſometimes an inch thick, which I have ſeen. If it be a ſmall froſt, the nails only of the windows, which faſten the latten together, will be tipt with white; all the nails of inſides of doors, and iron-work, will be adorned with the froſt, and going out of the door you will endanger your breath.

THE falconers here ſay, birds creep under the ſnow at nights.

ASSUREDLY the bears provide themſelves with a cave againſt the winter. I have kept a bear two days without meat or drink, he ſtill ſucking his paws, making a lather with his tongue; and, had he not ſmelt the meat of the houſe, which made him craving and clamorous, no doubt he might have been kept much longer upon his faſt.

12. A wind from the ſea there cauſes a thaw; ſo it does at *Archangel*, although it comes thither north.

I ſhall hereafter give you a catalogue of our plants, ſome of which are rare in *England*, but here in quantity, *viz.* lilium convallium, pyrola, bifolium, polygonatum, *&c.* I ſhall a little inform you concerning the vegetable lamb, which *Olearius* calls *baromets*.

13. BUT he told me they uſed very little phyſick, the air being ſo healthful, as that it is no rare thing to ſee people 80 or 100 years old; eſpecially the poorer ſort, that do not indulge themſelves with ſtrong drink.

14. THE ſame captain anſwered me, that in *Greenland* itſelf the north-eaſt winds were colder than any other, which yet he aſcribed in part to the ſituation of the country, thoſe winds blowing over vaſt tracts of ice, without ſea to mitigate the cold they communicated to the wind.

Particulars referable to the XIX*th title.*

1. LIeutenant G. *Drummond*, who for ſome years was governour of *Smolenſco*, told me, that he had many times barrels little leſs than our hogſheads of ſtrong beer, which being left night and day in the ſledges upon the ſnow, would be frozen all about next the caſk to a conſiderable thickneſs, ſo that the gimlet muſt pierce the ice a great way, before the veſſel would be ſet abroach; but then the liquor, which came forth, would not only be much ſtronger than the beer was at firſt, but much more pleaſantly taſted.

2. LIEUTENANT G. *Drummond* confirmed what others had told me, of the great noiſe, like the diſcharge of muſkets, that they hear in the wooden houſes, whoſe walls are made of fir-trees (unſquared, and only diſbarked,) upon very intenſe froſts; and he aſſured me, the great cracks or flaws, that appeared in the timber after theſe exploſions, were barely clefts made by the burſting of the trees, without any ſplinters, or other parts of the wood thrown off from the body of the timber.

3. THE two Swediſh Ambaſſadors aſſured me, that it is true, that in *Muſcovy*, and ſome other northern countries alſo, the hares are, as in theſe parts, grey, (*griſe*,) but ſnow-white in winter; and that they begin to change colour in autumn, (and to recover it in the ſpring.) And the elder of them, Monſieur *Coyet*, being aſked of me, if he himſelf had obſerved it, he aſſured me, that he had. It was likewiſe affirmed by the Swediſh Reſident, who was then preſent, and related it to me before them, that in the borders of *Muſcovy* he had ſeen ſtore of partridges milk-white: when I aſked, whether they changed colour in ſummer, or were not rather conſtantly white: he anſwered me, he could not tell, it being winter when he was there. And when I inquired, whether there were not ſome other beſides hares, that changed colour according to the ſeaſons, they all three told me, that ſquirrels, which in the ſummer are of the uſual colour, do in the winter turn grey, and recover their colour in the following ſummer.

THEY were pleaſed alſo to ſend me word the next day by an ingenious gentleman, ſon to Monſieur *Coyet*, that they had forgot to tell me, that whereas the river *Duna* divides *Livonia* and *Muſcovy*, on one ſide of the river the hares are of the ordinary colours, but on the other ſide white. So that when the hunters meet with any white hares on this ſide of the river, they ſay it is a *transfuga*.

4. AMONGST the odd effects of cold in *Ruſſia*, and ſome other countries, where that quality

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quality reigns in winter, it is none of the leaſt admired, that if a man be abroad in the air with a cane or ſtaff furniſhed with a metalline head, the cold is ſo intenſe in that compact body, that the tip of the tongue being applied to the metal, they will ſtick, and be (as it were) glewed together, ſo that a man cannot ſever them without great pain, and ſometimes without leaving ſome of the ſkin of his tongue behind upon the handle of the ſtaff; as it has been affirmed to me by eye-witneſſes of unqueſtionable credit. The reaſon of this odd phænomenon, as far as I can conjecture, may be the great and ſudden loſs of agitation occaſioned in the ſpittle and part of the tongue, by the great want of agitation in the parts of the metal that they touch. For if a bowl (for inſtance) of ivory meet in a direct line with another of the ſame bigneſs, that is already moving upon a billiard-table, it will communicate to it but a part of its own motion, and ſo retain the reſt for itſelf: but if the impelled bowl were at reſt, the impelling bowl will communicate to it all, or almoſt all its motion, and loſe as much itſelf, as may appear by its remaining quieſcent in the place of the other. I muſt not inlarge upon this ſubject of motion among bodies, that hit againſt others. But to apply the obſervation to my preſent purpoſe, it ſeems the metalline handle of the ſtick, by the intenſeneſs of the cold, has its parts ſo deprived of motion, that when thoſe of ſpittle and the tongue have communicated to them as much of their agitation as they can, there will not be between thoſe three bodies agitation enough to keep the ſpittle fluid, which conſequently being turned into ice, will ſtick to the two conſiſtent bodies it adhered to, namely, the tongue and the metal, and by this means will faſten them together.

In confirmation of this conjecture I ſhall add ſome other phænomena, which may be explicated by the help of it. And firſt we ſee, that in very froſty mornings the ice, that ſticks to glaſs-windows, often appears in the form of trees, or otherwiſe oddly and prettily figured. This is vulgarly ſo explained, as if the cold produced thoſe icy bodies on the outſide of the glaſs, through which, ſome fancy, that the vapours of the warm room penetrate: but it is plain, that this ice uſes to be formed within the room, as I have divers times obſerved, either by the thawing of it, or by ſcraping it off; ſo that it appears to be formed of vapours, which being carried to and fro by the air, when they chance to paſs along the glaſs-panes of the windows, which by the cold, that reigns in the external air in froſty weather, have loſt the wonted agitation of their parts, theſe vapours transfer ſo much of their motion to the glaſs, that they retain not enough to keep them fluid; the conſequence of which is their being turned into ice, which in very cold countries may be far thicker than it uſes to be here: inſomuch that a learned acquaintance of mine aſſured me, that he had in *Ruſſia* obſerved in ſome ſtoves, (where it is like the heat produced ſtore of vapours,) that the ice on the inſide of the windows was near an inch thick.

A note out of Martinius, *in his account of* China.

5. *In* Peking *elevatione Poli* 42. *gr. per integros quatuor menſes, facto circa Novembris medium initio, flumina omnia adeò duro concreſcunt gelu, ut currus, equoſque, ac graviſſima quæque onera glacies tutò ferat. Hæc plerumque concretio uno fit die; cùm non niſi pluribus, & quidem ab inferiori ſuperficie priùs, fuit liquefactio.* p. 27. ‘ *Martinius* in his account of *Peking* ‘ p. 27. tells us, that although the pole be not ‘ elevated above 42 degrees, yet for four ‘ whole months, from the middle of *November*, ‘ all the rivers are ſo bitterly frozen over, that ‘ the ice will ſafely bear coaches, and horſes, ‘ and all the heavieſt burdens. This congelation is for the moſt part made in one day; ‘ but the melting of the ice requires many, ‘ and begins from the lower ſurface.’

A note taken out of Martinius Cromerus *his* Polonia, *lib.* 1. *p.* 53, 54.

6. *Tanta eſt enim vis frigoris in his regionibus interdum, ut radicitus areſcant arbores, & aqua ex editiori loco effuſa, priuſquam terram contigerit, in glaciem concreſcat. Lacus quidem, & paludes, & flumina duobus tribuſve menſibus hibernis, nonnunquam autem vel in quintum vel ſextum uſque concreta glacie, non modo peditibus, verum etiam equitibus, & curribus ac plauſtris, quamvis oneratis, multis ſimul longo ſpatio pervia & ſecura præbent itinera. Equidem quodam tempore ultimo die menſis Martii* Viſtulam *in* Maſovia *per firmam adhuc glaciem, cum curru & quadrigis, & aliquot equitum comitatu tranſivi. Hâc etiam præteritâ hyeme in* Pruſſia *glacialis piſcatio in lacubus poſt initium Novembris cœpta, duravit per totum Martium, gelu autem per totum Aprilem.* ‘ So great is the violence of ‘ cold ſometimes in theſe countries, that trees ‘ wither at the roots; and water poured out ‘ from an high place, turns into ice before it ‘ comes to the ground. And truly the lakes, ‘ and marſhes, and rivers are ſo frozen for two ‘ or three months in winter, and ſometimes ‘ for five or ſix, that not only footmen, but ‘ alſo horſemen, and coaches, and waggons, ‘ though loaded, may for a long ſpace freely ‘ and ſecurely paſs over them. Truly once I ‘ paſſed over the *Weiſſel* in *Maſovia* upon the ‘ firm ice the laſt day of *March*, with a ‘ coach and four horſes, and a retinue of ſome ‘ horſemen; and this laſt winter in *Pruſſia* the ‘ fiſhing in the ice began in the lakes after ‘ the beginning of *November*, and continued ‘ all *March*, but froſt laſted all *April*.

A note taken out of Cromerus's Polonia, *lib.* 1. *p.* 68.

In cæteris lacubus, atque etiam in majoribus piſcinis & fluminibus tempore hyberno commodiores ferè ſunt piſcationes, quàm æſtate, pertuſâ certis intervallis glacie, retique per majus foramen in aquam immiſſo: quod longis funibus ad perticas alligatis hominum equorumve operâ longo ſpatio in diverſum tractum, coëuntibus rurſus piſcatoribus, alio foramine refertum extrahitur. ‘ In other lakes, and in the larger fiſh-ponds, ‘ and rivers, fiſhing is more commodious in ‘ winter

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'winter than in ſummer, the ice being broken 'in ſome places, and a net caſt into the water 'through a great hole, which by long ropes 'tied to poles, men and horſes draw different 'ways for a conſiderable ſpace; and then the 'fiſhermen meeting together, take it up well 'filled at another hole.'

7. AN ingenious phyſician confirmed to me upon trial, that the pummel of a ſword, that was expoſed to the winter-air in *Moſcow*, would ſtick to his tongue, that touches it therewith, and fetch off the ſkin, if he forcibly and ſuddenly pulled it away.

8. A GENTLEMAN, that came lately from *Warſaw*, told me, that in one night, or rather twelve hours, he obſerved this winter the ice next the ſurface of the water to reach four inches directly downwards.

9. THE old ſea-captain told me, that when he was in *Greenland*, and in thoſe artick regions, his appetite was ſo great, that he could well eat more in one day, than he could in a week or ten days here; and that accordingly he and others found themſelves ſtronger there than here, and more prone to venereal pleaſures.

HE told me alſo, that ſailing with intention to make ſome diſcovery into the artick circle, that after having ſailed a great while through a ſea exceeding blue and deep, they were as much ſurprized to find themſelves on a ſudden upon a ſea black almoſt like ink, which much frighted them, none of all their wanderers having met with a ſea of that colour. This made them, after many diſputes and doubts, reſolve to ſound both from their ſhip and ſhallop, but they could find no ground at ſeventy fathom.

10. A BOTTLE of ſtrong ſack, about two thirds filled, cracked, and the wine was frozen, *viz.* the phlegm, but no ice on the top, as in water; nor does the phlegm ever aſcend to the top, to be frozen in an entire body.

THIS ſack being preſently thawed, loſt its vigour, and ſo will any thing elſe.

11. THE froſt in theſe parts pierces the ground five foot, which the undertakers for digging a cellar for a friend of mine found by woful experience, being forced to make their way by fire, and ſometimes by cleaving the earth with wedges like a rock.

THE ice in *Siberia* in the river *Ob* is ſaid to be a fathom and a half thick, where they have in the whole year but twelve weeks of degelation.

THE rivers, that I have travelled over, have breathing-places for a mile, ſometimes half a mile, and a quarter, out of which comes a fume like that of the *Croſs-Bath* or *King's Bath* at the *Bath*. The like out of a cellar upon the opening of the door, enough to ſuffocate a man, if taken unawares.

DEATH by cold is not painful, eſpecially if the cold be very intenſe; as a friend of mine told me, who waiting upon his uncle here (a colonel) in quality of a page, he ſate upon the ſide of the ſledge, as ſervants do, and it being very cold, he ran to get himſelf ſome heat in his feet, and afterwards returned to ſit upon the ſledge, and found himſelf ſurprized with the cold; but had not the power to prevent the danger of ſuffocation by calling for help; yea, rather he ſeemed to be pleaſed with falling into a pleaſing ſleep, and ſo tumbled back upon his uncle's legs, which raiſed a ſuſpicion in him, that his couſin was frozen: and ſo making haſte to the next village, he rubbed him all over with ſnow ſtrenuouſly enough, and afterwards brought him into a warm room, which by degrees revived him, he feeling himſelf afflicted and pained in all his limbs with ſuch a tingling numbneſs, as they uſe to have who leaned too hard upon their elbows, but much more painful and amazing.

12. That cold dries exceſſively, appears by the ſtory of the cheeſes, and ſtock-fiſh, which is dryed in the wind, ſome of which is ſprinkled with ſalt. The earth will cleave with it, but I never obſerved it cracked with ſuch monſtrous hiatus, as *Olearius* reports; yet that may be true alſo. Where there is froſt long before the ſnow comes, the ice in rivers will have cracks.

ABOUT the middle of *December* being at *Yewſlave* in my lodging in a morning before day, the houſe being new, and expoſed to the north-eaſt wind, it gave a crack like a muſket.

Particulars referable to the XX*th Title.*

1. A Sealed glaſs-bubble with quickſilver in it weighed in the air, and being carefully counterpoiſed in water, that to my hand, whilſt I was ſitting by the fire-ſide, felt luke-warm, did, after ſnow and ſalt were applied on the out-ſide of the glaſs, that held the water, weigh $\frac{3}{4}$ of a grain, or ſomewhat better, before or juſt when there appeared a little film of ice on the inſide of the glaſs, containing the water, leſs than it did when the bubble was firſt put in.

2. A GLOBE of ſnow, rammed into the mould of juſt one inch diameter, weighed 112 grains.

3. A BULLET of ice of an inch diameter, made in the ſame mould, amounted to 2 drachms, 5 grains.

4. AFTER a long froſt and ſnow, a great deal of new ſnow being fallen laſt night, the liquor in the gaged weather-glaſs ſtands beneath the firſt mark, argues a more than ordinary froſt: and yet the mercury in the baroſcope ſtands at near $\frac{2}{8}$ beneath 29 inches, to which perhaps the high wind may contribute.

5. FOUR ounces of ſnow made up in a lump, were counterpoiſed in a pair of good ſcales, and expoſed in a froſty night after eleven o' clock without being taken out of the balance; the next morning between 9 and 10, there appeared a decrement of 29 or 30 grains, which ſeemed to have evaporated from the ſnow it ſelf: for though a ſmall portion of it (probably late in the morning) were melted in the ſcale, yet that liquor was but little, and amounted not to 8 grains, which was not a third of the weight, which the ſnow-ball had loſt; but ſuppoſing the decrement would be greater, if the ſnow had

had a greater ſuperficies, in reſpect of the bulk thereof, I cauſed the next night the following trial to be made, not being able to aſſiſt at it my ſelf.

THERE was taken ℥ ij of ſnow, which being made up into a kind of flat cake, was expoſed all night, which was froſty, in the abovementioned balance, and the next morning about eight a clock there appeared to have been loſt 55 grains, no water being found in the ſcale; and about two hours after, the decrement was found to be about 63 grains, none of the ſnow appearing to have melted in the ſcale.

One particular referable to the XXV*th Title.*

THE *Samojedes* clothe themſelves with *rein-deer* ſkins, the hair outward, which they find to be the warmeſt way: and I have found a pair of *cangies* (which are like high ſhoes with pecked toes of old *Chaucer*'s faſhion, which we wear without the leather) to be better than a pair of furred gloves. They are only proper for the ſledge, yet one may walk in the ſnow with them, which is ſo dry a ſnow, if it be duly cold weather, as it will not wet at all, nor endamage a ſcarlet covered all over with it, but bruſh or ſhake off like chaff.

OBSERVABLES upon a MONSTROUS HEAD.

Firſt Printed in the *Philoſophical Tranſactions*, N° v. p. 85. For *Monday*, July 3, 1665.

THIS was the head of a colt, repreſented in the annexed figure 4, firſt viewed by Mr. *Boyle*, who went into the ſtable where the colt lay, and got the head haſtily and rudely cut off, the body thereof appearing to his eye compleatly formed, without any monſtroſity to be taken notice of in it. Afterwards he cauſed it to be put into a veſſel, and covered with ſpirit of wine, thereby chiefly intending, to give good example, together with a proof, that by the help of the ſaid ſpirit, (which he hath recommended for ſuch properties in one of his Eſſays of the Uſefulneſs of Natural Philoſophy) the parts of animals, and even monſters, may in ſummer itſelf be preſerved long enough to afford anatomiſts the opportunities of examining them.

THE Head being opened, and examined, it was found,

FIRST, That it had no ſign of any noſe in the uſual place, nor had it any, in any other place of the head, unleſs the double bag C C, that grew out of the midſt of the forehead, were ſome rudiment of it.

NEXT, That the two eyes were united into one double eye, which was placed juſt in the middle of the brow, the noſe being wanting, which ſhould have ſeparated them, whereby the two eye-holes in the ſkull were united into one very large round hole; into the midſt of which, from the brain, entred one pretty large optick nerve, at the end of which grew a great double eye; that is, that membrane called ſclerotis, which contained both, was one and the ſame, but ſeemed to have a ſeam, by which they were joined, to go quite round it, and the fore or pellucid part was diſtinctly ſeparated into two corneas by a white ſeam that divided them. Each cornea ſeemed to have its iris, (or rain-bow-like circle) and apertures or pupils diſtinct; and upon opening the cornea, there was found within it two balls, or cryſtalline humours, very well ſhaped; but the other parts of it could not be ſo well diſtinguiſhed, becauſe the eye had been much bruiſed by the handling, and the inner parts confuſed and diſlocated. It had four eye-brows, placed in the manner expreſt in figure 4, by *a a*, *b b*; *a a* repreſenting the lower, and *b b*, the upper eye-lids.

LASTLY, That juſt above the eyes, as it were in the midſt of the forehead, was a very deep depreſſion, and out of the midſt of that grew a kind of double purſe or bag, C C, containing little or nothing in it; but to ſome it ſeemed to be a production of the matter deſigned for the noſe, but diverted by this monſtrous conception; perhaps the proceſſus mammillares joined into one, and covered with a thin hairy ſkin.

Some ANATOMICAL OBSERVATIONS of MILK found in Veins inſtead of BLOOD; and of GRASS found in the Wind-pipes of ſome Animals.

Firſt Printed in the *Philoſophical Tranſactions*, N° vi. p. 100. For *Monday*, November 6. 1665.

A Curious perſon wrote not long ſince from *Paris*, that there they had, in the houſe of a phyſician, newly opened a man's vein, wherein they found milk, inſtead of blood. This being imparted to Mr. *Boyle* at *Oxford*, his anſwer was, that the like obſervation about white blood had been made by a learned phyſician of his acquaintance

quaintance; and the thing being by him looked upon as remarkable, he was deſirous to have it very circumſtantially from the ſaid phyſician himſelf, before he would ſay more of it. The next month may bring us in this account.

THE other particular mentioned in the title of this head, came in a letter ſent alſo by Mr. *Boyle*, in theſe words:

I ſhall acquaint you, that two very ingenious men, Dr. *Clarke* and Dr. *Lower*, were pleaſed to give me an account of a pretty odd kind of obſervation: one of them aſſuring me, that he had ſeveral times, in the lungs of ſheep, found a conſiderable quantity of graſs in the very branches of the aſpera arteria: and the other relating to me, that a few weeks ſince, he, and a couple of phyſicians, were invited to look upon an ox, that had for two or three days almoſt continually held his neck ſtreight up, and was dead of a diſeaſe, the owner could not conjecture at; whereupon, the parts belonging to the neck and throat, being opened, they found, to their wonder, the aſpera arteria in its very trunk all ſtuffed with graſs, as if it had been thruſt there by main force: which gives a juſt cauſe of marvelling and inquiring, both how ſuch a quantity of graſs ſhould get in there; and how, being there, ſuch an animal could live with it ſo long.

Of a Place in *England*, where, without petrifying Water, WOOD is turned into STONE.

Firſt Printed in the *Philoſophical Tranſactions*, N° VI. as above.

THE ſame ſearcher of nature, that was alledged in the immediately precedent obſervations, did impart alſo the following, in another letter from *Oxford*, where he ſaith,

I was a while ſince viſited by a gentleman, who tells me, that he met with a place in theſe parts of *England*, where, though there be no petrifying ſpring (for that I particularly aſked) wood is turned into ſtone in the ſandy earth itſelf, after a better manner than by any water I have yet ſeen: for I had the curioſity to go to look upon pieces of wood he brought thence, and hope for the opportunity of making ſome trials to examine the matter a little further, than I have been yet able to do. *Thus far that letter.*

SINCE which time, he was pleaſed to give this further information of the ſame matter, with a mantiſſa of ſome other particulars, belonging to this ſubject, in theſe words:

I was lately making ſome trials with the petrified wood I told you of, which I find to be a very odd ſubſtance, wonderfully hard and fixed. If I had opportunity to reprint the *Hiſtory of Fluidity and Firmneſs*, I could add divers things about ſtones, that perhaps would not be diſliked; and I hope, if God vouchſafe me a little leiſure, to inſert ſeveral of them in fit places of that hiſtory, againſt the next edition. Here is a certain ſtone, that is thought to be petrified bone, being ſhaped like a bone, with the marrow taken out; but with a fit menſtruum, I found that I could eaſily diſſolve it, like other ſoft ſtones: and poſſibly it may prove as fit as oſteocolla, for the ſame medicinal uſes.

A Farther ACCOUNT of an OBSERVATION about WHITE BLOOD.

Firſt Printed in the *Philoſophical Tranſactions*, N° VI. p. 117.

SINCE the printing of the former ſheet, there is this farther account from the ſame hand, Mr. *Boyle*.

I have at length, according to your deſire, received from the ingenious Dr. *Lower* an account in writing of the obſervation about chyle found in the blood; which though you may think ſtrange, agrees well with ſome experiments of his and mine, not now to be mentioned. The relation, though ſhort, comprizing the main particulars of what he had more fully told me in diſcourſe, I ſhall give it you with little or no variation from his own words.

A maid, after eating a good breakfaſt, about ſeven in the morning, was let blood about eleven the ſame day in her foot; the firſt blood was received in a porringer, and within a little while it turned very white; the laſt blood was received in a ſaucer, which turned white immediately, like the white of a cuſtard. Within five or ſix hours after, he (the phyſician) chanced to ſee both, and that in the porringer was half blood and half chyle, ſwimming upon it like a ſerum as white as milk, and that in the ſaucer all chyle, without the leaſt appearance of a drop of blood; and when he heated them diſtinctly over a gentle fire, they both hardened: as the white of an egg when it is heated, or juſt as the ſerum of blood doth with heating, but far more white. This maid was then in good health, and only let blood becauſe ſhe never had her courſes, yet of a very florid clear complexion.

HYDRO-

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HYDROSTATICAL PARADOXES,

Made out by

NEW EXPERIMENTS,

For the moſt part PHYSICAL and EASY.

The PUBLISHER's ADVERTISEMENT to the READER.

WHEN the author writ the following treatiſe, he had a deſign, as appears by ſome paſſages in the preface, to publiſh together with it ſome things, which he had divers years before provided for an Appendix to his Phyſico-mechanical treatiſe about the Air: but part of the Appendix conſiſting of experiments, which the author has ſeveral times made, but truſting to his memory, did not think it neceſſary to record, when he came to recollect particulars, he found, that ſome years, which had paſſed, ſince divers of them were tried, and variety of intervening occurrents, had made it unſafe for him to rely abſolutely upon his memory for all the circumſtances fit to be ſet down in the hiſtorical part of the deſign'd Appendix. And therefore he reſolv'd to repeat divers experiments and obſervations, that he might ſet down their phænomena, whilſt they were freſh in his memory, if not objects of his ſenſe. But though, when he writ the following Preface he did it upon a probable ſuppoſition, that he ſhould ſeaſonably be able to repeat the intended trials; yet his expectation was ſadly diſappointed by that heavy, as well as juſt viſitation of the plague, which happened at *London*, whilſt the author was in the country; and which, much earlier than was apprehended, began to make havock of the people at ſo ſad a rate, that not only the glaſsmen there were ſcattered, and had, as they themſelves advertiſed him, put out their fires, but alſo carriers, and other ways of commerce (ſave by the poſt) were ſtrictly prohibited betwixt the parts he reſided in, and *London*; which yet was the only place in *England*, whence he could furniſh himſelf with peculiarly ſhaped glaſſes, and other mechanical implements requiſite to his purpoſes: and the ſame calamity continuing ſtill, without yet affording us any certain ground of determining, when it will end, the author chuſes rather to ſuffer the following Paradoxes to come abroad without the Appendix, (which is no way neceſſary to them, whatever they may be to it,) than any longer put off thoſe ingenious perſons, that ſollicited the publication of them.

The PREFACE.

THE riſe of the following treatiſe being a command impoſed on me by the Royal Society, the reader will, I hope, need no more, than this intimation, to keep him from wondering to find ſome paſſages worded as parts of a diſcourſe pronounced before an aſſembly; it being not unuſual (though not neceſſary) to preſent either in writing, or by word of mouth, together with the experiments made before that illuſtrious company, an hiſtorical account of them.

BUT, becauſe it is probable, that ſome reader will deſire to be ſatisfied about other particulars relating to the publication of this treatiſe, I preſume it will not be amiſs, both to ſay ſomething of the reaſons, why I publiſh it as the firſt part of the preſent Appendix to my *Phyſico-mechanical Experiments*, and to give ſome account of the manner of writing it.

I HAD quickly both an opportunity, and an invitation to enlarge the papers, I was to read, beyond the limits of a bare deſcription of the phænomena, and matters of fact, by my having been, through ſome intervening accidents, ſo hindered from exhibiting them altogether, that I was deſir'd to bring in an account in writing, that might be regiſter'd (how little ſoever worthy of ſuch company) in the Society's collection of philoſophical papers, for the ſake of thoſe members, who could not be preſent at all the experiments; ſo that, finding ſome enlargements expected from me, I was eaſily induced to add the explications of the phænomena I deſcribed, whilſt I perceiv'd, that by a ſmall addition of pains I might much gratify divers ingenious friends, that were not ſo well verſed in Hydroſtaticks, as in the other parts of real learning.

HAVING thus been induced to enlarge the account of my experiments, till it had attained

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tained the bulk it is now arrived at, I confeſs I was, without much difficulty, perſuaded, that to ſuffer it to paſs abroad * in the company of the Appendix, wherewith it is publiſhed, would not prove unacceptable to the curious, no more than an improper introduction to the reſt of my Appendix, and that for ſeveral reaſons.

For, firſt, the Hydroſtaticks is a part of philoſophy, which, I confeſs, I look upon as one of the ingenioſeſt doctrines, that belong to it; theorems and problems of this art being moſt of them pure and handſome productions of reaſon, duly exerciſed on attentively conſidered ſubjects, and making in them ſuch diſcoveries as are not only pleaſing, but divers of them ſurpriſing, and ſuch as would make one at firſt wonder, by what kind of ratiocination men came to attain the knowledge of ſuch unobvious truths. Nor are the delightfulneſs and the ſubtilty of the Hydroſtaticks the only things, for which we may commend them: for there are many, as well of the more familiar, as of the more abſtruſe phænomena of nature, that will never be thoroughly underſtood, nor clearly explicated by thoſe, that are ſtrangers to the Hydroſtaticks; upon whoſe principles depend, beſides many other things, the explications of moſt of the phyſico-mechanical experiments, we have ventured to preſent the publick, and the deciſion of thoſe many controverſies, which they and the phænomena of the Torricellian experiment have occaſioned among the modern inquirers into nature.

But the uſe of this art is not alone ſpeculative, but practical, ſince not only the propoſitions it teaches, may be of great importance to navigation, and to thoſe that inquire into the magnitudes and gravities of bodies, as alſo to them that deal in ſalt-works; but that the Hydroſtaticks may be made divers ways ſerviceable to the chymiſts themſelves, to whoſe art that doctrine ſeems to be ſo little of kin, I might here manifeſt, if I could think it fit to tranſcribe, what I have † elſewhere delivered to that purpoſe.

But that, which invited me to write ſomething of this part of philoſophy, is, not only that I think it conſiderable, but that, notwithſtanding its being ſo, I find it but very little, and not very happily cultivated. For, being nor looked upon as a diſcipline purely mathematical, the generality of mathematicians have not in their writings ſo much as taken notice of it, much leſs improv'd it. And ſince the admirable *Archimedes*, who, in his little tract *De Inſidentibus Humido*, has left us three or four very excellent propoſitions, (but proved by no very eaſy demonſtrations) among divers others, that have more of geometrical ſubtility than uſefulneſs; thoſe mathematicians, that (like *Marinus Ghetaldus*, *Stevinus*, and *Galileo*) have added any thing conſiderable to the Hydroſtaticks, have been (that I know of) very few; and thoſe too have been wont to handle them rather as geometricians, than as philoſophers, and without referring them to the explication of the phænomena of nature. And as for the Peripateticks and other ſchool-philoſophers, though on ſome occaſions, as when they tell us, that water weighs not in water, nor air in air, they deliver aſſertions about matters belonging to the Hydroſtaticks; (which term, in this treatiſe, I often take in a large ſenſe, becauſe moſt of the things delivered about the weight of bodies, may, by eaſy variations, be made applicable to other fluids;) yet they are ſo far from having illuſtrated, or improved them, that they have but broached, or credited, divers of the moſt erroneous conceits, that are entertained about them. So that, there being but few treatiſes written about the Hydroſtaticks, and thoſe commonly bound up among other mathematical works, and ſo written, as to require mathematical readers, this uſeful part of philoſophy has been ſcarce known any farther, than by name, to the generality even of thoſe learned men, that have been inquiſitive into the other parts of it, and are deſervedly reckoned among the ingenious cultivators of the modern philoſophy. But this is not all; for ſome eminent men, that have of late years treated of matters hydroſtatical, having been prepoſſeſſed with ſome erroneous opinions of the peripatetick ſchool, and finding it difficult to conſult experience about the truth of their concluſions, have interwoven divers erroneous doctrines among the ſounder propoſitions, which they either borrowed from *Archimedes*, and other circumſpect mathematicians, or deviſed themſelves; and theſe miſtakes being deliver'd in a mathematical dreſs, and mingled with propoſitions demonſtrably true, the reputation of ſuch learned men, (from which I am far from deſiring to detract,) and the unqualifiedneſs of moſt readers to examine mathematical things, has procured ſo general an entertainment for thoſe errors, that now the Hydroſtaticks is grown a part of learning, which it is not only difficult to attain, but dangerous to ſtudy.

Wherefore, though neither the occaſion and deſign of this treatiſe exacted, nor my want of ſkill and leiſure qualified me to write either a body, or elements of Hydroſtaticks; yet I hoped I might do ſomething, both towards the illuſtrating, and towards the reſcue of ſo valuable a diſcipline, by publiſhing the enſuing tract; where I endeavour to diſprove the received errors, by eſtabliſhing paradoxes contrary to them, and to make the truths the better underſtood and received, partly by a way of explicating them unemploy'd in hydroſtatical books, and partly by confirming the things I deliver, by phyſical and ſenſible experiments. And over and above this, the more to recommend Hydroſtaticks themſelves to the reader, I have, beſides the paradoxes oppoſed to the errors I would diſprove, taken occaſion by the ſame way to make out ſome of the uſefulleſt of thoſe hydroſtatical truths, that

* About this paſſage, ſee the Publiſher to the Reader.

† Chiefly in ſeveral places of the unpublished part of the Treatiſe of the *Uſefulneſs of Experimental Philoſophy*.

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that are wont to ſeem ſtrange to beginners.

If it be here demanded, why I have made ſome of my explications ſo prolix, and have on ſeveral occaſions inculcated ſome things; I anſwer, That thoſe, who are not uſed to read mathematical books, are wont to be ſo indiſpoſed to apprehend things, that muſt be explicated by ſchemes; and I have found the generality of learned men, and even of thoſe new philoſophers, that are not ſkilled in mathematicks, ſo much more unacquainted, than I before imagined, both with the principles and theorems of Hydroſtaticks, and with the ways of explicating and proving them, that I feared, that neither the paradoxes themſelves, that I maintain, nor the hypotheſes about the weight and preſſure of the air, upon which little leſs than my whole pneumatical book depends, would be thoroughly underſtood without ſuch a clear explication of ſome hydroſtatical theorems, as, to a perſon not verſed in mathematical writings, could ſcarce be ſatisfactorily delivered in few words. And therefore, though I do not doubt, that thoſe, who are good at the moſt compendious ways of demonſtrating, will think, I might in divers places have ſpared many words without injury to my proofs; and though I am myſelf of the ſame mind I expect to find them of; yet I confeſs, that it was out of choice, that I declin'd that cloſe and conciſe way of writing, that in other caſes I am wont moſt to eſteem. For writing now not to credit myſelf, but to inſtruct others, I had rather geometricians ſhould not commend the ſhortneſs of my proofs, than that thoſe other readers, whom I chiefly deſigned to gratify, ſhould not thoroughly apprehend the meaning of them.

But this is not all, for which I am to excuſe myſelf to mathematical readers. For ſome of them, I fear, will not like, that I ſhould offer for proofs ſuch phyſical experiments, as do not always demonſtrate the things, they would evince, with a mathematical certainty and accurateneſs; and much leſs will they approve, that I ſhould annex ſuch experiments to confirm the explications, as if ſuppoſitions and ſchemes, well reaſoned on, were not ſufficient to convince any rational man about matters hydroſtatical.

In anſwer to this, I muſt repreſent, that in phyſical enquiries it is often ſufficient, that our determinations come very near the matter, though they fall ſhort of a mathematical exactneſs. And I chuſe rather to preſume upon the equity of the reader, than to trouble him and myſelf with tedious circumlocutions, to avoid the poſſibility of being miſunderſtood, or of needing his candour. And we ſee, that even mathematicians are wont, without finding any inconvenience thereby, to ſuppoſe all perpendicular lines, made by pendulous bodies, to be parallel to one another: though indeed they are not; ſince, being produced, they would meet at the centre of the earth. And to preſume, that the ſurface of every calm water, in a veſſel, is parallel to the horizon, and conſequently a plane; though, in ſtrictneſs, themſelves think it the portion of a ſphere; and though alſo I have uſually obſerved it to be higher, where it is almoſt contiguous to the ſides of the veſſel, than it is in other places.

Moreover, ſince we find, that though water will be uniformly raiſed in pumps to ſeveral heights, but not to thirty-five foot; and will, in ordinary open pipes, be almoſt of the ſame level within and without, but not if the pipe be extraordinary ſlender; upon theſe, and divers other ſuch conſiderations, I may have ſometimes made uſe of expreſſions that ſeemed not poſitive and determinate enough to be employed about matters, to which mathematical demonſtrations are thought applicable. But I elſewhere give an account of the ſcruples I have about ſuch demonſtrations, as they are wont to be applied to phyſical matters. And, in the preſent paradoxes, I think I have not done nothing, if in my hydroſtatical explications I have made it appear, that in experiments made with ſuch liquors and glaſſes, as I employed, the rules will hold without any ſenſible, or at leaſt any conſiderable error; for thereby we may learn the truth of many things, for the main, though in ſome we ſhould not have attained to the exactneſs of meaſures, and proportions, which yet our endeavours may aſſiſt others to arrive at.

And as for my confirmation of hydroſtatical propoſitions by phyſical experiments, if ſome readers diſlike that way, I make no doubt, but that the moſt will not only approve it, but thank me for it. For though, in pure mathematicks, he, that can demonſtrate well, may be ſure of the truth of a concluſion, without conſulting experience about it; yet becauſe demonſtrations are wont to be built upon ſuppoſitions or poſtulates; and ſome things, though not in arithmetick or geometry, yet in phyſical matters, are wont to be taken for granted, about which men are liable to ſlip into miſtakes; even when we doubt not of the ratiocination, we may doubt of the concluſion, becauſe we may of the truth of ſome of the things it ſuppoſes. And this conſideration, if there were no other, will, I hope excuſe me to mathematicians, for venturing to confute ſome reaſonings, that are given out for mathematical demonſtrations. For I ſuppoſe it will be conſidered, that thoſe, whoſe preſumed demonſtrations I examine, though they were ſome of them profeſſors of mathematicks, yet did not write meerly as mathematicians, but partly as naturaliſts; ſo that to queſtion their tenets ought not to diſparage thoſe, as well certain, as excellent and moſt uſeful ſciences, pure mathematicks, any more than that the mathematicians, that follow the Ptolemaick, the Copernican, the Tychonian, or other ſyſtems of the world, write books to manifeſt one another's paralogiſms in aſtronomical matters: and therefore (to proceed to what I was about to ſay) it cannot but be a ſatisfaction to a wary man to conſult ſenſe about thoſe things, that fall under the cogniſance

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ſance of it, and to examine by experiences, whether men have not been miſtaken in their hypotheſes and reaſonings; and therefore the learned *Stevinus* himſelf (the chief of the modern writers of Hydroſtaticks) thought fit, after the end of his Hydroſtatical Elements, to add in an appendix ſome pragmatical examples, (as he calls them) that is, mechanical experiments (how cogent I now inquire not) to confirm the truth of his tenth propoſition, to which he had, not far from the beginning of his book, annexed what he thinks a mathematical demonſtration. And, about the very ſubjects we are now upon, the following paradoxes will diſcover ſo many miſtakes of eminent writers, that pretend to have mathematically demonſtrated what they teach, that it cannot but make wary naturaliſts (and it is chiefly to gratify ſuch, that I publiſh this) be ſomewhat diffident of concluſions, whoſe proofs they do not well underſtand. And it cannot but, to ſuch, be of great ſatisfaction to find the things, that are taught them, verified by the viſible teſtimony of nature herſelf. The importance of this ſubject, and the frequent occaſion I have to make uſe of this kind of apology, will, I hope, procure me the reader's pardon, if I have inſiſted ſomewhat long upon it.

AFTER what has been hitherto diſcourſed, it will be eaſy for me to give an account, why I premiſe theſe hydroſtatical paradoxes to the reſt of the Appendix, wherewith they are * now publiſh'd: for ſince a great part of my work, in that Appendix, was to be a further explication of ſome things delivered in the book it is ſubjon'd to, and the vindication of them from invalid objections; and ſince I have generally obſerved, that the objections, that have been, either publickly or privately, made againſt the explications and reaſonings contained in that book, were wont to proceed from unacquaintedneſs, either with the true notion of the weight and ſpring of the air, as I maintain them, or with the principles and theorems of Hydroſtaticks, or elſe from erroneous conceits about them; I thought it would much conduce to both the forementioned ends of my Appendix, if I cleared up that doctrine, to which my experiments and reaſonings have been all along conſonant; and whoſe being either not known, or miſunderſtood, ſeems to have occaſioned the objections, that have been hitherto made againſt the hypotheſes I have propoſed, or the explications I have thence given. And however, ſince the proofs, I offer for my opinions, are for the moſt part drawn from experiments new and eaſy, and that my aim is but to diſcover truths, or make them out by clearer explications, without ſuppoſing, like thoſe I diſſent from, any thing, that is either precarious, or ſcarce, if at all, intelligible; I hope, that if I ſhould not prove happy enough to reach my ends, yet the ingenious and equitable reader will approve my deſign, and be advantaged by my experiments. Of which ſome of the chiefeſt, and ſome of the moſt difficult, having been ſeen (divers of them more than once) by the Royal Society itſelf, or by inquiſitive members of it; it will, I preſume, be but a reaſonable requeſt, if the reader, that ſhall have the curioſity to try them over again, be deſired not to be haſty in diſtruſting the matters of fact, in caſe he ſhould not be able at firſt to make every thing ſucceed according to expectation. For, as eaſy as I have endeavoured to make theſe experiments, yet I dare not promiſe myſelf, that they will all of them be privileged from the fate, whereto I have obſerv'd other phyſico-mathematical ones to be not ſeldom obnoxious, from ſome unheeded phyſical circumſtance, by which thoſe, that are not acquainted with the ſubtleties of nature, or, at leaſt for the time, do not ſufficiently conſider them, are apt to be impoſed upon.

THIS advertiſement will, perhaps, be beſt illuſtrated and recommended by an inſtance; and therefore I ſhall ſubjoin one, that will poſſibly ſeem ſomewhat odd.

IT has been taken notice of by two or three ingenious modern mathematians, and I have had occaſion to make it out by particular experiments, that warm water is lighter *in ſpecie*, than cold; whence it has been deduced, that wax, and other bodies, very near equiponderant with common water, will ſwim in that which is cold, and ſink in that which is hot, or luke-warm. Which experiment, though as it may be (and perhaps it has been) tried, I readily allow to be agreeable to the known laws of the Hydroſtaticks, yet I have ſometimes undertaken, that the trial ſhould have a quite contrary effect. To that purpoſe, having taken ſome yellow bees-wax, which was formed into a pellet of the bigneſs of a cherry, and, by the help of a little lead, was made ſo near equiponderate to cold water, that, being but a very little heavier, a very ſmall diminution of its weight would make it emerge, I removed it out of the very cold water into ſome, that had been purpoſely made luke-warm (or a little more than ſo,) where it quickly, ſomewhat to the wonder of the lookers on, appeared to ſwim on the top of the water. And that it might not be ſuſpected, that it was ſupported by any viſible bubbles, which I have obſerved, in ſome caſes, to buoy up even heavy bodies, and deceive the unſkilful, or unattentive; I briſkly enough ducked the bullet two or three times under water to throw them off, notwithſtanding which it conſtantly return'd to float; and yet, being removed again into the ſame cold water it had been taken out of, and ducked as before, to free it from adherent bubbles, it lay quietly at the bottom, and, though raiſed ſeveral times to the upper part of the water, would immediately ſubſide to the very loweſt. Now that, which invited me to promiſe an experiment, which ſeems to contradict the principles of the Hydroſtaticks, was not any diſtruſt of thoſe principles themſelves, but a conjecture, that as by warmth the water would be made a little lighter *in ſpecie* than it was before;

* An account of this paſſage alſo may be had from the Publiſher's Advertiſement to the Reader.

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before; ſo, by the ſame warmth, the ſpirituous and more agitable parts of the wax, whoſe texture is looſe enough, would be ſomewhat (though not viſibly) expanded, and would by that expanſion gain a greater advantage towards floating, than the increaſed lightneſs of the water would give it diſpoſition to ſink. And I confirm'd this conjecture by a farther experiment, which at firſt was itſelf ſomewhat ſurpriſing to the beholders. For when the wax was firſt taken out of the cold water, and immediately immerſed in the warm, it would readily enough ſink; and being (with a quill or a knife) raiſed to the top of the water, it would again fall down, but more ſlowly than at the beginning; and after ſome few minutes, if it were rais'd to the upper parts of the water, it would remain afloat. (And I have known it, when it had remained a while longer at the bottom, ſo to emerge, that if I were ſure no unheeded bubbles had been newly generated, and held it up, it might be ſaid to emerge of its own accord;) as on the other ſide, being put into the cold water, as ſoon as ever it was taken out of the warm, it would at the very firſt float, and being then knocked downwards, it would, readily enough, regain the upper part of the water: but if I continued to ſend it downwards about ſix or ſeven times (more or fewer) ſucceſſively, it would emerge every time more ſlowly than other, and at length not emerge at all, even when I tried it in water made heavy, by being highly infrigidated with ſalt and ſnow placed about the glaſs. Which phænomena I had thought it reaſonable to expect, becauſe I preſumed, that the wax, being removed immediately out of the warm water into the cold, muſt require ſome time to loſe the adventitious expanſion, which the warmth had given it, and muſt be deprived of it by degrees, by the coldneſs of the water, into which the wax was transferred. As, on the other ſide, there muſt be ſome time neceſſary for ſo little a warmth, as that of the tepid (or little more than tepid) water, to give the wax that addition of dimenſions, (which alſo it muſt receive by degrees) that was neceſſary, in ſpite of the rarefaction of the water, to make it float. I might add, that theſe trials were repeated, for the main, with more bullets of wax than one, and that they ſucceeded far otherwiſe, when, inſtead of a piece of wax, we employed a poiſed glaſs-bubble, in which the temperature could make either no change at all, or no conſiderable change of dimenſions. And to theſe I might add other circumſtances, if I did not remember, that I mention theſe trials but occaſionally, and to make the caution, formerly recommended to the reader, appear not to be impertinent; ſince a hydroſtatical experiment, true in itſelf, may eaſily miſcarry by overlooking ſuch circumſtances, as it is not eaſy to be aware of.

But, by this advertiſement, I would by no means divert men from being diffident of hydroſtatical traditions and experiments. For, beſides the many erroneous opinions, there are matters of fact, whoſe truth, though not queſtion'd, but built upon, I think ought to be brought to trial. For, even whilſt I was concluding this preface, I found, that divers, even of the moderns, and particularly a very learned man, that has lately written of Hydroſtaticks, have much troubled themſelves to render a reaſon, why, ſince, according to their doctrine, water weighs not in water, wooden veſſels, though of a ſubſtance lighter than water, being by leaks, or otherwiſe, fill'd with water, ſhould ſink and remain at the bottom of the water: whereas, judging this phænomenon diſagreeable to what I look upon as the laws of the Hydroſtaticks, I was confirm'd in that opinion, by having had the curioſity to make ſome trials of it, with four or five veſſels of differing ſhapes and ſizes, whereof two were of wax; which, though a matter but very little lighter than water, I could not ſink, or keep ſunk by pouring water into them, or ſuffering them to fill themſelves at leaks made near the bottom: and if they were depreſſed by force or weights, they, as alſo the wooden veſſels, would, upon the removal of the impediment, (and ſometimes with the cavity upwards) emerge. And I am the more ſolicitous to have things in the Hydroſtaticks duly aſcertained, becauſe the weighing of bodies in liquors may hereafter appear to be one of the general ways I have employed, and would recommend, for the examining of almoſt all ſorts of tangible bodies.

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HYDROSTATICAL PARADOXES,

Made out by

NEW EXPERIMENTS,

Preſented to the ROYAL SOCIETY, (the Lord Viſcount BROUNCKER being then Preſident) *May* 1664.

MY LORD,

TO obey the orders of the Society, that forbid the making of preſaces and apologies, in accounts of the nature of that, which you expect from me; I ſhall, without any further preamble, begin with taking notice, that upon peruſal of Monſieur *Paſcal*'s ſmall French book, which was put into my hands, I find it to conſiſt of two diſtinct treatiſes; the one, *of the Æquilibrium* of liquors, as he calls it; and the other, *of the weight of the maſs of the Air.*

As for this latter, (which I ſhall mention firſt, becauſe I can in very few words diſpatch the little I have to ſay of it;) though it be an ingenious diſcourſe, and contains things, which, if they had been publiſhed at the time, when it is ſaid to have been written, would probably have been very welcome to the curious; yet I have very little elſe to ſay of it in this place, in regard that, ſince that time, ſuch kind of experiments have been ſo proſecuted, that I preſume it is needleſs, and would not be acceptable to repeat, what Monſieur *Paſcal* has written, in this Society, which has ſeen the ſame truths, and divers others of the like nature, more clearly made out by experiments, which could not be made by Monſieur *Paſcal*, and thoſe other learned men, that wanted the advantage of ſuch engines and inſtruments, as have in this place been frequently made uſe of.

WHEREFORE, having already at a former meeting given you, by word of mouth, an account of Monſieur *Paſcal*'s ingenious invention, of a pair of bellows without vent, to meaſure the various preſſure of the atmoſphere; I remember nothing elſe, that needs hinder me from proceeding to the other part of his book, *The Treatiſe of the Æquilibrium of Liquors.*

THIS I find ſo ſhort, and ſo worthy of the author, that to give you all, that I judge worth taking notice of in it, would oblige me to tranſcribe almoſt the whole tract; and therefore I ſhall rather invite you to read the whole, than divert you from the deſign by culling out any part of it; yet, if you will not be ſatisfied without ſomething of more particular, I ſhall be obliged to tell you, that the diſcourſe conſiſting partly of concluſions, and partly of experiments, the former ſeemed to me to be almoſt all of them (there being but few that I doubt of) conſonant to the principles and laws of the Hydroſtaticks. But as for the latter, the experimental proofs he offers of his opinions are ſuch, that, I confeſs, I have no mind to make uſe of them.

AND the reaſons, why, notwithſtanding that I like moſt of Monſieur *Paſcal*'s aſſertions, I decline employing his way of proving them, are principally theſe:

FIRST, Becauſe though the experiments he mentions be delivered in ſuch a manner, as is uſual in mentioning matters of fact; yet I remember not, that he expreſly ſays, that he actually tried them, and therefore he might poſſibly have ſet them down, as things, that *muſt* happen, upon a juſt confidence, that he was not miſtaken in his ratiocinations. And of the reaſonableneſs of this doubt of mine, I ſhall ere long have occaſion to give an inſtance.

SECONDLY, Whether or no Monſieur *Paſcal* ever made theſe experiments himſelf, he does not ſeem to have been very deſirous, that others ſhould make them after him. For he ſuppoſes the phænomena he builds upon to be produced fifteen or twenty foot under water. And one of them requires, that a man ſhould ſit there with the end of a tube leaning upon his thigh; but he neither teaches us, how a man ſhall be enabled to continue under water, nor how, in a great ciſtern full of water, twenty foot deep, the experimenter ſhall be able to diſcern the alterations, that happen to mercury, and other bodies at the bottom.

AND thirdly, Theſe experiments require not only tubes twenty foot long, and a great veſſel of, at leaſt, as many feet in depth, which will not in this country be eaſily procured; but they require braſs cylinders, or plugs, made with an exactneſs, that, though eaſily ſuppoſed by a mathematician, will ſcarce be found obtainable from a tradeſman.

THESE difficulties making the experiments propoſed by Monſieur *Paſcal* more ingenious than practicable, I was induced, on this occaſion, to bethink myſelf of a far more expeditious way to make out, not only moſt of the concluſions, wherein we agree, but others, that he mentions not; and this with ſo much more eaſe and clearneſs, that not only this illuſtrious aſſembly, but perſons, no more than moderately verſed in the vulgar principles of the Hydroſtaticks, may eaſily enough apprehend, what is deſigned to be delivered, if they will but bring with them a due attention, and minds diſpoſed to prefer reaſon and experience

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experience to vulgar opinions and authors: which laſt clauſe I annex, becauſe the following diſcourſe, pretending to confute ſeveral of thoſe, challenges a right to except againſt their authority.

IT not being my preſent taſk to deliver the elements, or a body of Hydroſtaticks, but only ten or twelve paradoxes, which I conceive to be proveable by this new way of making them out; I ſhall, to avoid confuſion, deliver them in as many diſtinct propoſitions: after each of which, I ſhall endeavour in a proof, or an explication, to ſhew, both that it is true, and why it ought to be ſo. To all theſe I ſhall, to avoid needleſs repetitions, premiſe a word or two by way of poſtulatum, or lemma.

AND becauſe I remember, to what aſſembly I addreſs this diſcourſe, I ſhall make uſe of no other, than an eaſy ſuppoſition I met with, in a ſhort paper (about a mercurial phænomenon) brought in a year or two ſince to this learned Society, by a deſervedly famous member of it *: for though his ſuppoſal be made upon occaſion of an experiment of another nature, than any of the enſuing, it may be eaſily accommodated to my preſent purpoſe.

THIS poſtulatum, or lemma, conſiſts of three parts; the firſt of them more, and the two laſt leſs principal.

SUPPOSE we then, firſt, that if a pipe open at both ends, and held perpendicular to the horizon, have the lower of them under water, there paſſes an imaginary plane or ſurface, which touching that orifice, is parallel to the horizon, and conſequently parallel, as to ſenſe, to the upper ſurface of the water; and this being but a help to the imagination, will readily be granted.

SECONDLY, To this it will be conſonant, that each part of this deſignable ſurface will be as much, and no more preſſed, as any other equal part of it, by the water that is perpendicularly incumbent on it. For the water, or other fluid, being ſuppoſed to be of an homogeneous ſubſtance, as to gravity, and being of an equal height upon all the parts of the imaginary ſurface; there is no reaſon, why one part ſhould be more preſſed by a perpendicular pillar of that incumbent fluid, than any other equal part of the ſame ſurface by another perpendicularly incumbent pillar of the ſame, or equal baſis and height, as well as of the ſame liquor.

BUT thirdly, Though whilſt our imaginary ſurface is equally preſſed upon in all parts of it, the liquor muſt retain its former poſition; yet, if any one part comes to have a greater weight incumbent on it, than there is upon the reſt, that part muſt be diſplaced, or depreſſed, as it happens, when a ſtone, or other body heavier than water, ſinks in water. For wherever ſuch a body happens to be underneath the water, that part of the imaginary plane, that is contiguous to the lower part of the ſtone, having on it a greater weight, than other parts of the ſame ſurface, muſt needs give way; and this will be done ſucceſſively, till the ſtone arrive at the bottom. And if, on the other ſide, any part of the imaginary ſurface be leſs preſſed upon than all the reſt, it will, by the greater preſſure on the other parts of the ſurface, be impelled upwards, till it have attained a height, at which the preſſure (of the raiſed water, and the lighter or floating body, if any there be, that leans upon it, and gravitates together with it upon the ſubjacent part of the imaginary ſurface) will be equal to that, which bears upon the other parts of the ſame ſurface.

AND becauſe this ſeems to be the likelieſt thing to be queſtioned in our † aſſumption, though he, that conſiders it attentively, will eaſily enough be induced to grant it; yet I ſhall here endeavour to evince it experimentally, and that by no other way of proof, than the ſame I employ all along this preſent diſcourſe.

TAKE then a cylindrical glaſs pipe, of a convenient bore, open at both ends; let the tube be ſteadily held perpendicular to the horizon, the lower end of it being two or three inches beneath the ſurface of a convenient quantity of water, which ought not to fill the glaſs veſſel, that contains it. The pipe being held in this poſture, it is manifeſt, that the water within the pipe will be almoſt in a level with the ſurface of the water without the pipe, becauſe the external and internal water (as I am wont for brevity's ſake to call them) have free intercourſe with one another, by the open orifice of the immerſed end of the pipe; yet I thought fit to inſert the word *almoſt*, becauſe, if the pipe be any thing ſlender, the ſurface of the water in it will always be ſomewhat higher than that of the water without it, for reaſons, that it is not ſo neceſſary we ſhould now inquire after, as it is, that we ſhould here deſire to have this taken notice of once for all; that miſtakes may be avoided without a troubleſome repetition of the difference in heights of the ſurface of liquors within pipes and without them, in caſe they be any thing ſlender.

THE pipe being held in the newly-mentioned poſture, if you gently pour a convenient quantity of oil upon the external water, you ſhall ſee, that as the oil grows higher and higher above the ſurface of that water, the water within it will riſe higher and higher, and continue to do ſo, as long as you continue to pour on oil; of which the reaſon ſeems manifeſtly to be this; that in the imaginary plane, that paſſes by the orifice of the immerſed end of the pipe, all that is not within the compaſs of the orifice, is expoſed to an additional preſſure from the weight of the oil which ſwims upon the water, and that preſſure muſt ſtill be increaſed, as there is more and more oil poured on: whereas a circular part of the imaginary plane, equal to the orifice of the glaſs, is by the ſides of the pipe fenced from the immediate preſſure of the oil;

* That excellent mathematician, the learned Dr. *Wallis*, Savilian Profeſſor of Geometry.

† This Experiment, and the Explication of it, if to ſome they ſhould here ſeem ſomewhat obſcure, will be eaſily underſtood by the Figures and Explications belonging to the firſt enſuing paradox.

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oil; ſo that all thoſe other parts of the water, being far more preſſed, than that part, which is comprehended within the cavity of the tube, and conſequently the preſſed parts of the external water are, by the equal gravitation of the oil upon the parts of the external water, impelled up into the cavity of the pipe, where they find leſs reſiſtance than any where elſe, till they arrive at ſuch a height, that the cylinder of water within the pipe does as much gravitate upon the ſubjacent part of the imaginary ſurface, as the water and oil together do upon every other equal part of the ſame ſurface or plane.

BUT as well the former lemma, as this experiment, will be ſufficiently both cleared and confirmed by the following explications; to which I ſhould for that reaſon forthwith proceed, were it not, that, ſince divers paſſages of the following treatiſe ſuppoſe the air to be a body not devoid of weight, which yet divers learned adherents to the Peripatetick philoſophy do reſolutely deny, it ſeems requiſite to premiſe ſomething for the proof of this truth.

AND though I think the arguments we have employed to that purpoſe already, do ſtrongly evince it; yet, if I may be allowed to anticipate one of my own experiments of the Appendix, I ſhall give an inſtance of the weight of the air, not liable ſo much as to thoſe invalid objections, which ſome of the Ariſtotelians have made againſt thoſe proofs, wherewith we have been ſo happy, as to ſatisfy the learnedeſt even of our profeſſed adverſaries.

WE cauſed then to be blown at the flame of a lamp a bubble of glaſs, (of about the bigneſs of a ſmall hen-egg) which, that it might be light enough to be weighed in exact ſcales, ought to be of no greater thickneſs than is judged neceſſary to keep it from being (when ſealed up with none but very much expanded air in it) broken by the preſſure of the ambient atmoſphere. This bubble was (like a pear with its ſtem) furniſhed with a very ſlender pipe of glaſs, at which it was blown, that it might be readily ſealed up; and then, (the air within it being by the flame of the lamp gradually rarified, as much as conveniently could be) whilſt the body of the bubble was exceeding hot, the newly-mentioned ſtem was nimbly put into the middle of the flame; where, by reaſon of its ſlenderneſs, the glaſs, which was exceeding thin, was immediately melted, whereby the bubble was hermetically ſealed up. This glaſs being permitted leiſurely to cool, I could afterwards keep it by me an hour, or a day, or a week, or longer, if I thought fit; and when I had a mind to ſhew the experiment, I put it in one of the ſcales of an exact balance, that would turn, perhaps, with the thirtieth, or fiftieth, or a leſs part of a grain; and having carefully counterpoiſed it, I then warily broke off the ſealed end, placing a ſheet of paper juſt under the ſcale, to receive the fragments of the glaſs; and putting in again thoſe fragments, that ſcale, wherein the glaſs was, would conſiderably preponderate; which it muſt do upon the account of the weight of air, there being no other cauſe, either needful, or juſtly aſſignable, but the weight of the air that ruſhed into the cavity of the glaſs, as finding leſs reſiſtance there than elſewhere, by reaſon that the included air had its ſpring much weakened by its great expanſion.

THIS experiment I many times tried, ſometimes before ſome Virtuoſi, and ſometimes before others; who all allowed it to be concluſive. For here it could not be objected, as againſt the weighing of air in a bladder, (which objections yet I could eaſily anſwer, if it were now proper) that the air, which ponderates, is ſtuffed with the effluvia of him, that blows the bladder, and (beſides that) is not air in its natural ſtate, but violently compreſſed. For here it is the free air, and in its wonted laxity, that makes the glaſs preponderate.

AND that there is a great ingreſs of the exteanal air, is evident by theſe three phænomena. The one, that if you lend an attentive ear, you ſhall plainly hear a kind of whiſtling noiſe to be made by the external air, as it ruſhes violently in upon the breaking of the glaſs; the other, that the rarefaction of the air ſealed up in the bubble being very great, there is a great deal of ſpace left for the ambient air to fill upon its admiſſion; and the greatneſs of this rarefaction may be gueſſed at, both by the breaking of ſuch bubbles now and then by the preſſure of the external air, which is not competently aſſiſted by the internal to reſiſt; and alſo by the third phænomenon I intended to take notice of, namely, That, if, inſtead of breaking off the ſealed end of the glaſs in the air, you break it under water, that liquor will, by the preſſure of the atmoſphere, be forced to ſpring up like an artificial fountain into the cavity of the bubble, and fill about three qurters of it. By which laſt circumſtance I gather, that the weight of the air is more conſiderable, than even many, who admit the air to have weight, ſeem to imagine. For we muſt not ſuppoſe, that all the air contained in the bubble, when broken, weighs no more, than the weight requiſite, in the oppoſite ſcale, to reduce the balance to an æquilibrium; ſince this additional weight is only that of the air, that intrudes on the breaking of the glaſs; which air, by the obſervations newly mentioned to have been made with water, appears to be but about three quarters of the whole air contained in the broken bubble; and yet, according both to our eſtimate, and that of divers Virtuoſi, and ſome of them eminent mathematicians, when the capacity of the bubble was ſhort of two cubical inches, (and ſo proportionably in other glaſſes) the nice balance we uſed, manifeſted the newly-admitted air to amount to, ſometimes, near half a grain, and ſometimes beyond it.

AND becauſe one of the laſt experiments that I made to this purpoſe, with ſealed bubbles, was none of the leaſt accurate, I ſhall conclude this ſubject with the following account of it:

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A THIN glaſs bubble, blown at the flame of a lamp, and hermetically ſealed, when the contained air was exceedingly rarified, was counterpoiſed in a nice pair of ſcales; and then the ſealed *apex* being broken off, and put again into the ſame ſcale, the weight appeared to be increaſed by the re-admitted air, a pretty deal above $\frac{11}{16}$ths, and conſequently very near, if not full $\frac{3}{4}$ of a grain. Laſtly, having by ſome ſlight (for it is no very eaſy matter) filled it with common water, we weighed the glaſs and water together, and found the latter, beſides the former, to amount to nine hundred and ſix grains. So that ſuppoſing, according to our former eſtimate, countenanced by ſome trials, that the re-admitted air, which amounted to $\frac{3}{4}$ of a grain, filled but $\frac{3}{4}$ of the whole cavity of the bubble, the air that was in it, when ſealed, poſſeſſing one quarter of that cavity, the whole air contained in the bubble may be reaſonably preſumed to weigh a whole grain; in which caſe we might conclude (abſtracting from ſome little niceties, not fit to be taken notice of here, as elſewhere) that the water in our experiment weighed very little more, than nine hundred times as much as an equal quantity of air. And therefore, though we allow, that in an experiment ſo diligently made as this was, the air pre-exiſtent in the bubble did not adequately poſſeſs ſo much as a fourth part, but about a fifth, or a ſixth of its cavity, the air will yet appear ſo heavy, that this experiment will agree well with thoſe others, recorded in another treatiſe, wherein we aſſigned *(numero rotundo)* a thouſand to one, for the proportion wherein the ſpecifick gravity of water exceeds that of air.

PARADOX I.

That in water, and other fluids, the lower parts are preſſed by the upper.

PROVIDE a glaſs-veſſel of a convenient height and breadth, A, B, C, D. filled with water almoſt to the top; then take a glaſs-pipe, open at both ends, cylindrical, and of a ſmall bore, (as about the eighth, or ſixth part of an inch in diameter.) Put the lower end of this pipe into clear oil, or ſpirit of turpentine; and having, by ſuction, raiſed the liquor to what part of the pipe you think fit, as ſoon as it is there, you muſt, very nimbly removing your lips, ſtop the upper orifice with the pulp of your finger, that the raiſed liquor may not fall back again: then, taking the pipe, and that liquor out of the oil of turpentine, place it perpendicularly in the glaſs of water, ſo as that the ſurface of the oil in the pipe be ſomewhat higher than that of the water without the pipe; and having ſo done, though you take off your finger from the upper orifice of the pipe, the oil will not fall down at the lower orifice, though that be open, but will remain ſuſpended at the ſame height, or near thereabouts, that it reſted at before.

Now oil of turpentine, being a heavy fluid, does, as ſuch, tend downwards; and not being ſtopped by the glaſs itſelf, whoſe lower orifice is left open, it would certainly fall down through the pipe, if it were not kept ſuſpended by the preſſure (upwards) of the water beneath it; there appearing no other cauſe, to which the effect can reaſonably be aſcribed, and this being ſufficient to give an account of it, as we ſhall preſently ſee. For that it is not any contrariety in nature, betwixt the oil and the water, as liquors, that will not mingle, is evident from hence; that if you had removed your finger, when the pipe was not ſo deeply immerſed in the glaſs, but that the ſurface of the oil in the pipe was an inch or two more elevated above that of the water in the glaſs, than in our preſent caſe we ſuppoſe it to be; the oil, notwithſtanding its preſumed contrariety to water, would have freely ſubſided in the pipe, till it had attained an equipollency of preſſure with the external water.

THE reaſon, therefore, of the phænomenon ſeems to be plainly this: Suppoſing the imaginary ſurface, on which the extremity Q of the pipe PQ leans, to be GH. If that part of the ſurface, on which the oil leans at Q, be as much, and no more charged, or preſſed upon by the weight of the incumbent cylinder of oil QX, than the other parts of the ſame imaginary ſurface GH are by the water incumbent on them, there is no reaſon, why that part at Q ſhould be diſplaced, either by being depreſſed by the weight of the cylinder of oil XQ, or raiſed by the equal preſſure of water upon the other parts of the ſuperficies GH.

AND that this æquilibrium, betwixt the oil and the water, is the true cauſe of the phænomenon, may be confirmed by obſerving what happens, if the altitude of either of the two liquors be altered in relation to the other.

AND, firſt, we have already taken notice, that if the cylinder of oil reach, in the pipe, much higher than that of the ſurface of the water, the oil will deſcend: of which the reaſon is, becauſe, the deſignable ſurface GH being more charged at Q than any where elſe, the part Q, being unable to reſiſt ſo great a preſſure, muſt neceſſarily be thruſt out of place by the deſcending oil.

SECONDLY, This ſubſiding will continue but till the ſurface of the oil in the pipe be fallen almoſt as low, as that of the water without the pipe; becauſe then, and not before, the parts at Q are but as much preſſed by the oil, as the other parts of the ſurface GH are by the water, that leans upon them.

THIRDLY, It is a concluding circumſtance to our preſent purpoſe, that if, the oil and water being in an æquilibrium, you gently lift up the pipe, as from Q to S, the depth of the water being leſſened, the oil in the pipe will grow preponderant, and therefore will fall out in drops or globules; which, by the greater ſpecifick gravity of the water, will be buoyed up to the top of the liquor, and there float: and ſtill, as you lift up the pipe higher and higher towards the ſurface LM, more and more of the oil will run out. But if you ſtop

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the pipe any where in its aſcent, as at S, the effluxion of the oil will likewiſe be ſtopped. And at the imaginary ſuperficies J K, as by reaſon of the ſhallowneſs of the water from L to J, or M to K, the preſſure of the water upon the other parts of the ſurface is not near ſo great, as it was upon the ſurface G H, where the water had a greater depth; ſo, by reaſon of the proportionate effluxion of the oil, whilſt the pipe was lifted up from Q to S, the remaining cylinder of oil, incumbent on S, is not able to preſs that part of the ſuperficies J K more ſtrongly, than the other parts of the ſame ſuperficies are preſſed by the water incumbent on them. And if the pipe be lifted up, till the lower orifice be almoſt raiſed to V, that is, almoſt as high as the uppermoſt ſurface of the water L M, ſo much of the oil will, for the reaſon already given, run out, that there will ſcarce be any left in the pipe T V.

FOURTHLY, But if, when the pipe reſts at the ſurface G H, where the oil is in an æquilibrium with the water, you ſhould, inſtead of lifting it from Q to S, thruſt it down from Q to O; then the external water would not only ſuſtain the oil, but make it aſcend in the pipe to a height equal to the diſtance E G; and ſo the pipe will contain, beſides a longer cylinder of oil Æ W, a ſhorter one of water Æ O. For the pipe being transferred from the poſition P Q, to the poſition O N, there is a new imaginary ſurface E F, that paſſes by the lower orifice of the pipe. Now the part of this ſurface at O will not, by the incumbent oil alone, be preſſed as much as the other parts of the ſame ſurface are by the incumbent water. For the oil alone was but in æquilibrium with the water, when it was no deeper than L G, or H M; ſo that the other parts of the ſuperficies E F being more preſſed upon by the water, than the part at O by the oil, the oil muſt give place, and be buoyed up by the water, (which, if it were not for the weight of the oil, would be impelled up into the pipe full as high as the ſurface of the external water) till the preſſure of the admitted water O Æ, and the cylinder of oil Æ W, do both together gravitate as much upon the part O, as the reſt of the incumbent water does upon the other parts of the ſame ſuperficies E F.

FIFTHLY, and laſtly, It is very agreeable to what has been delivered, touching the æquilibrium of the oil and water in the pipe P Q, that the ſurface X, of the oil in the pipe, will not be of the ſame level with L M, that of the external water, but a little higher than it. For though the ſlenderneſs of the pipe do ſomewhat contribute to this effect, yet there would be an inequality, though not ſo great, betwixt theſe ſurfaces, upon this account; that oil of turpentine being *in ſpecie*, (as they ſpeak in the ſchools) that is, bulk for bulk, a lighter liquor than water, it is requiſite, that the height of it, incumbent on the part Q, be greater than that of the water on the other parts of the ſame ſurface G H, to make the preſſure of the oil, on the part it leans upon, equal to the preſſure of the water on the other parts of the ſurface. And if the inequality were greater betwixt the ſpecifick gravities of theſe two liquors, the inequalities betwixt the ſurface X and the ſurface L M would be alſo greater; as may be tried by ſubſtituting, for common water, oil of tartar *per deliquium*, which is a ſaline liquor much heavier than it. And that, in caſe the pipe contain not a lighter liquor than the external fluid, the ſurface of the liquor in the pipe will not be higher, than that of the liquor without it, we ſhall by and by have opportunity to manifeſt by experience.

FROM what has been hitherto ſhewn, we may ſafely infer the propoſition, upon whoſe occaſion all this has been delivered. For ſince the oil, in a pipe open at both ends, may be kept ſuſpended in any part under water, as at Q, becauſe it is there in an æquilibrium with the external water; and ſince, being lifted up in the water, as from Q to S, the oil can no longer be kept ſuſpended, but, by its own gravity, will run out: and ſince, in a word, the deeper the water is, the greater weight and preſſure is required in the cylinder of oil, to be able to countervail the preſſure of the water, and keep itſelf from being lifted up thereby; there ſeems no cauſe to doubt, but that the parts of the water incumbent on the ſuperficies G H do more preſs that ſuperficies, than the parts of the water contiguous to the ſuperficies J K do preſs that; and conſequently, that the parts of the water, that are under the uppermoſt ſurface of it, are preſſed by thoſe of the ſame fluid, that are directly over them. As we ſaw alſo, that the upper parts of the oil, whilſt the pipe was in raiſing from Q to S, depreſſed the lower ſo much, as to force them quite out of the pipe; there being, in theſe caſes, no reaſon, why the lowermoſt parts of a liquor ſhould preſs more, or have a ſtronger endeavour againſt any other liquor (or any other body) the higher the liquor incumbent reaches, if theſe inferiour parts derived their preſſure only from their own particular gravity, (which is no greater, than that of the other homogeneous parts of the liquor:) and therefore they muſt derive the great force, wherewith they preſs, from the weight of the incumbent parts, which, conſequently, muſt be allowed to preſs upon them.

BUT, before I proceed to the following propoſitions, it will not be amiſs to mention here, once for all, a few advertiſements, to avoid the neceſſity of repeating the ſame things in the ſequel of the diſcourſe.

AND firſt, What is here ſaid of the preſſure of the parts of water upon one another, and the other affections, that we ſhall attribute to it, in the following paper, are to be applied to heavy fluids in general, unleſs there ſhall appear ſome particular cauſe of excepting ſome of them in particular caſes.

SECONDLY, Whereas I lately intimated, that the inequality betwixt the ſurfaces of the oil in the pipe, and of the external water, was in part to be aſcribed to the ſlenderneſs of the

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the pipe to be employed in theſe experiments; I did it for this cauſe, that, whatever the reaſon of it be, (which we need not here inquire after,) we are aſſured by experience, as we have elſewhere ſhewn, that, when glaſs-pipes come to be ſlender, water, and many other liquors (though not quickſilver) will have within them a higher ſurface, than that of the ſame liquor without them; and this inequality of ſurfaces (as far as we have yet tried) increaſes with the ſlenderneſs of the pipe. But this, as to our preſent experiment, is a matter of ſo little moment, that it may ſuffice to have intimated, that we did not overſee it.

THIRDLY, Wherefore, notwithſtanding this little inconvenience of ſlender glaſſes, we think it expedient to employ ſuch in the following experiments, becauſe we found, that in thoſe of a wide bore, upon ſuch little inequalities of preſſure, as are not eaſily to be avoided, the oil and water will paſs by one another in the cavity of the pipe, and ſo ſpoil the experiment, which requires, that the oil within the pipe be kept in an intire and diſtinct body.

FOURTHLY, Common oil and water, or any other two liquors, that will not mingle, may ſerve the turn in moſt of theſe experiments; but we rather chuſe oil of turpentine, becauſe it is light and thin, clear and colourleſs, and may be eaſily had in quantities, and is not ſo apt to ſpot one's clothes, or obſtinately to adhere to the porous bodies it chances to fall on, as common, and other expreſſed oils. And for their ſakes, to whom the odour is offenſive, we preſently correct it, by mingling with it a convenient quantity of oil of rhodium, or ſome other chymical oil, that is odoriferous.

FIFTHLY, Oil of turpentine, though it be not reckoned among the ſaline menſtruums, will yet (as we elſewhere note) work upon copper, and ſo by digeſting it upon crude filings of that metal, we obtain a deep green liquor, which may be made uſe of inſtead of the limpid oil, to make the diſtinction of the liquors more conſpicuous.

SIXTHLY, And for the ſame purpoſe we often uſe, inſtead of clear water, a ſtrong decoction of brazil, or log-wood, or elſe red ink itſelf: I ſay, a ſtrong decoction, becauſe unleſs the liquor be ſo deeply tinged, as to appear opacous in the glaſs, when it comes into the ſlender pipe, its colour will be ſo diluted, as to be ſcarce diſcernible.

SEVENTHLY, In the ſhape of the glaſs-veſſel, we need not be curious; though that of a wide-mouthed jar, expreſſed in the ſcheme, be for ſome uſes more convenient than other ſhapes. The depth of theſe glaſſes, and the length of the pipes, muſt be determined by the experiments, about which one means to employ them. To make out the firſt paradox already proved, a glaſs of about five or ſix inches deep, and a pipe about as many inches long, will ſerve the turn: but for ſome others of the following experiments, tall cylindrical glaſſes will be requiſite; and for ſome, broad ones likewiſe will be expedient.

EIGHTHLY, One muſt not be diſcouraged by not being able, at the firſt or ſecond time, to ſuck up oil of turpentine to the due height, and ſtop it with one's finger from relapſing; but one muſt try again, and again; eſpecially ſince many trials of this kind may be made in a few minutes: and for beginners it is a ſafe and good, though not the ſhorteſt way, to ſuck up rather more liquor than one judges will be needful; becauſe having filled the pipe to that height, you may, by letting in the air warily and ſlowly between the orifice of the glaſs and the pulp of your finger, ſuffer ſo much liquor to run out of the pipe, as will reduce it to the height you deſire; and there, by cloſe ſtopping the orifice with your finger, you may keep it ſuſpended as long as you pleaſe, and immerſe it into any heterogeneous liquor, and take it out again at pleaſure without ſpilling any of it. By which ſlight expedient alone, I can decline ſeveral difficulties, and do many things, which, according to Monſieur *Paſcal*'s way, require a great deal of trouble and apparatus to be performed,

LASTLY, In ſuch experiments, where it may be of uſe, that there be a conſiderable diſparity betwixt the two unmingled liquors, we may (as is above intimated) inſtead of fair water, imploy *oleum tartari per deliquium*, and tinge it with brazil or cochineel; from either of which, but eſpecially from the latter, it will obtain an exceeding deep redneſs. And where one would avoid ſtrong ſcents and oilineſs, he may, if he will be at the charge, imploy oil of tartar *per deliquium*, inſtead of fair water; and highly rectified ſpirit of wine, inſtead of oil of turpentine. For theſe two liquors, though they will both readily mingle with water, will not with one another; and if a great quantity of ſome other liquor be to be ſubſtituted for ſimple water, when theſe chymical liquors are not to be had in plenty, one may imploy (as we have done) a very ſtrong ſolution made of ſea-ſalt, and filtred through cap-paper: this brine being near about as limpid as common water, and far heavier than it. And for a curioſity, we have added to the two lately mentioned liquors (oil of tartar, and ſpirit of wine) ſome oil of turpentine, and thereby had three liquors of different gravities, which will not by ſhaking be brought ſo to mingle, as not quickly to part again, and retire each within its own ſurface; and by thruſting a pipe with water in the bottom of it (placing alſo one's finger upon the upper orifice) beneath the ſurface of the lowermoſt of theſe liquors, and by opportunely raiſing or depreſſing it, one may ſomewhat vary the experiment in a way not unpleaſant, but explicable upon the ſame grounds with the reſt of the phænomena mentioned in this diſcourſe.

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PARADOX II.

That a lighter fluid may gravitate or weigh upon a heavier.

I KNOW that this is contrary to the common opinion, not only of the ſchools, but even of divers modern mathematicians, and writers of Hydroſtaticks, ſome of whom have abſolutely rejected this paradox, though they do but doubt of the truth of the former.

BUT when I conſider, that whether the cauſe of gravity be the pulſion of any ſuperiour ſubſtance, or the magnetical attraction of the earth, or whatever elſe it be, there is in all heavy bodies, as ſuch, a conſtant tendency towards the center, or lowermoſt parts of the earth; I do not ſee, why that tendency or endeavour ſhould be deſtroyed by the interpoſition of any other heavy body; though what would otherwiſe be the effect of that endeavour, namely, an approach towards the center, may be hindred by another body, which being heavier than it, obtains by its greater gravity a lower place; but then the lighter body tending downwards, muſt needs preſs upon the heavier, that ſtands in its way, and muſt, together with that heavier, preſs upon whatever body it is, that ſupports them both, with a weight conſiſting of the united gravities of the more, and the leſs heavy body.

BUT that, which keeps learned men from acknowledging this truth, ſeems to be this, that a lighter liquor (or other body) being environed with a heavier, will not fall down, but emerge to the top: whence they conclude, that, in ſuch caſes it is not to be conſidered as a heavy, but as a light body.

BUT to this I anſwer, that though in reſpect of the heavier liquor, the leſs heavy may, in ſome ſenſe, be ſaid to be light; yet notwithſtanding that relative or comparative levity, it retains all its abſolute gravity, tending downwards as ſtrongly as before; though, by a contrary and more potent endeavour upwards of the contiguous liquor (whoſe lower parts, if leſs reſiſted, are preſſed upwards by the higher, elſewhere incumbent; according to the doctrine partly delivered already, and partly to be cleared by the proof of the next propoſition,) its endeavour downward is ſo ſurmounted, that it is forcibly carried up. Thus when a piece of ſome light wood being held under water, is let go, and ſuffered to emerge, though it be buoyed up by the water, whoſe ſpecifick gravity is greater, yet even whilſt it aſcends it remains a heavy body; ſo that the aggregate of the water, and the aſcending wood, weighs more than the water alone would do; and when it floats upon the upper part of the water, as part of it is extant above the ſurface, ſo part of it is immerſed beneath it, which confirms what we were ſaying, that a lighter body may gravitate upon a heavier.

And thus there is little doubt to be made, but that if a man ſtand in one of the ſcales of a balance with a heavy ſtone tied to his hand, and hanging freely by his ſide, if then he lift that weight as high above his head as he can, notwithſtanding that the ſtone's motion upwards makes it ſeem a light body, in reſpect of the man, whoſe body it leaves beneath it, yet it does not, either during its aſcent or after, loſe any thing of its connatural weight. For the man, that lifts it up, ſhall feel its tendency downwards to continue, though his force, being greater than that tendency, be able, notwithſtanding that tendency, to carry it up: and when it is aloft, it will ſo preſs againſt his hand, as to offend, if not alſo to bruiſe it; and the ſtone, and the man, that ſupports it, will weigh no leſs in the ſcale he ſtands in, than if he did not at all ſupport it, and they were both of them weighed apart.

LIKEWISE, if you put into one ſcale a wide-mouthed glaſs full of water, and a good quantity of powdered common ſalt; and into the other ſcale a counterpoiſe to them both; you may obſerve, that, though at the beginning the ſalt will manifeſtly lie at the bottom, and afterwards by degrees be ſo taken up into the body of the liquor, that not a grain will appear there; yet nevertheleſs (as far as I can judge by my experiments) the weight in that ſcale will not be diminiſhed by the weight of as much ſalt as is inceſſantly either carried up, or ſupported by the reſtleſs motion of the diſſolving corpuſcles of the water; but both the one and the other, (allowing for what may evaporate) will concurrently gravitate upon the ſcale, that the glaſs containing them leans on.

BUT of this more elſewhere. Now to prove the propoſition, by the new method, we have propoſed to ourſelf, in this diſcourſe:

TAKE a ſlender glaſs-pipe, and having ſucked up into it fair water, to the height of three or four inches, ſtop nimbly the upper orifice with your finger, and immerſe the lower into a glaſs full of oil of turpentine, till the ſurface of the oil in the veſſel be ſomewhat higher than that of the water in the pipe: then removing your finger, though the pipe do thereby become open at both ends, the water will not fall down, being hindered by the preſſure of the oil of turpentine. As will be obvious to them, that have attentively conſidered the explication of the former paradox; there being but this difference between this experiment and that there explained, that here the water is in the pipe, and the oil in the veſſel, whereas there the oil was in the pipe, and the water in the veſſel. And if you either pour more oil into the glaſs, or thruſt the pipe deeper into the oil, you ſhall ſee that the water will be buoyed up towards the top of the pipe; that is, a heavier liquor will be lifted up by a lighter. And ſince, by the explication of the firſt propoſition, it appears, that the reaſon, why the liquor is in this caſe raiſed in the pipe, is the gravity of the liquor that raiſes it, we muſt allow, that a lighter liquor *in ſpecie* may by its gravity preſs againſt a heavier.

AND it agrees very well with our explication, both of this, and of the firſt experiment;

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riment; that as there, the ſurface of the oil in the pipe was always higher than that of the water without it, becauſe the oil being the lighter liquor, a greater height of it was required to make an æquilibrium; ſo in our preſent experiment the ſurface of the liquor in the pipe will always be lower than that of the oil without it. For in the imaginary plain E F, the cylinder of water J G, contained in the pipe J H, will, by reaſon of its greater gravity, preſs as much upon the part J, as the diſtilled oil (K E, J L,) being a lighter liquor, can do upon the other parts of the ſame ſuppoſed plain E F, though the oil reached to a greater height above it.

See the ſecond figure.

THIS ſecond paradox, we have hitherto been diſcourſing of, may be alſo proved by what we formerly delivered, to make out the truth of the third part of the lemma premiſed to theſe propoſitions.

BUT becauſe this and the former paradox are of importance, not only in themſelves, but to the reſt of this treatiſe, and are likely in moſt readers, to meet with indiſpoſition enough to be received, I will ſubjoin in this place a couple of ſuch experiments, as will not, I hope, be unacceptable; that I deviſed, the one to confirm this ſecond paradox, and the other to prove the firſt.

SOME of the gentlemen now preſent may poſſibly remember, that about the end of the year, that preceded the two laſt, I brought into this place a certain new inſtrument of glaſs, whereby I made it appear, that the upper parts of water gravitate upon the lower; which I did, by ſinking a body, that was already under water, by pouring more water upon it.

BUT that experiment belonging to other papers, I ſhall here ſubſtitute another performed by an inſtrument, which, though it makes not ſo fine a ſhew, may be more eaſily provided, and will as well as that other (though you were pleaſed to command that from me) ſerve to make out the ſame truth; which I ſhall apply myſelf to do, as ſoon as I have, by an improvement of the expedient I am to propoſe, made good my late promiſe of confirming the ſecond paradox.

AND before I can well draw an argument from theſe experiments, for either of the propoſitions to be proved by them, I muſt briefly repeat what I have elſewhere delivered * already (on another occaſion) touching the cauſe of the ſinking of ſuch bubbles; namely, that the bubble X conſiſting of glaſs, which is heavier *in ſpecie* than water; and air, which is lighter *in ſpecie* than water; and, if you pleaſe, alſo of water itſelf, which is of the ſame ſpecifick gravity with water; as long as this whole aggregate of ſeveral bodies is lighter than an equal bulk of water, it will float; but in caſe it grows heavier than ſo much water, it muſt, according to the known laws of the hydroſtaticks, neceſſarily ſink, (being not otherwiſe ſupported.) Now when there is any competent preſſure (whether produced by weight or otherwiſe,) upon the water, in which this bubble is for the moſt part immerſed, becauſe the glaſs is a firm body, and the water, though a liquor, either ſuffers no compreſſion, or but an inconſiderable one; the air included in the bubble, being a ſpringy and very compreſſible body, will be compelled to ſhrink, and thereby poſſeſſing leſs room than it did before, the contiguous water will ſucceed in its place; which being a body above a thouſand times heavier than air, the bubble will thereby become heavier than an equal bulk of water, and conſequently will ſink: but if that force or preſſure be removed, the impriſoned air will, by its own ſpring, free itſelf from the intruding water; and the aggregate of bodies, that makes up the bubble, being thereby grown lighter than an equal bulk of water, the ſubſided bubble will preſently emerge to the top.

Fig. III.

THIS explication of the cauſes of the ſinking of bubbles agrees in ſome things with the doctrine of the learned Jeſuits *Kircher* and *Schottus*, and ſome other writers, in the account they give of thoſe two experiments, that are commonly known by the name, the one of the Roman, the other of the Florentine experiments. But there are alſo particulars, wherein I (who have never a recourſe to a *fuga vacui*,) diſſent from their doctrine: the principles, I go upon, having invited and aſſiſted me to make that experiment, afford me ſome new phænomena, which agree not with their opinions, but do with mine: but I forbear to mention them here, becauſe they belong to other papers; and for the ſame reaſon I omit ſome acceſſion of ludicrous phænomena (as they call them) which I remember I have ſometimes added to thoſe, which our induſtrious authors have already deduced from thoſe experiments.

THESE things being premiſed, I proceed to the confirmation of the ſecond paradox, by the following experiment:

TAKE a long glaſs-pipe, ſealed, or otherwiſe exactly ſtopped at one end, and open at the other; (whoſe orifice, if it be no wider than that it may be conveniently ſtopped with a man's thumb, the tube will be the fitter to exhibit ſome other phænomena.) Into this pipe pour ſuch a quantity of common water, as that there may be a foot, or half a yard, or ſome other competent part left unfilled, for the uſe to be by and by mentioned. Then having poiſed a glaſs-bubble with a ſlender neck, in ſuch a manner, as that, though it will keep at the top of the water, yet a very little addition of weight will ſuffice to ſink it, put this bubble thus poiſed into the tube; where it will ſwim in the upper part of the water, as long as it is let alone; but if you gently pour oil of turpentine upon it, (I ſay gently, to avoid confounding the liquors) you will perceive, that, for a while, the bubble will continue where it was: but if you continue pouring on oil, till it have attained a ſufficient height above the water, (which it will be eaſy to perceive, becauſe thoſe two liquors will keep themſelves diſtinct) you

* In certain notes upon ſome of the Phyſico-mechanical Experiments touching the air,

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you ſhall ſee the bubble ſubſide, till it fall to the bottom, and continue there as long as the oil remains at the height above the water.

The reaſon of this phænomenon, according to our doctrine, is this, that the oil of turpentine, though a lighter liquor than water, yet gravitates upon the ſubjacent water, and by its preſſure forces ſome of it into the cavity of the bubble at the open orifice of its neck, whereby the bubble, which was before but very little leſs heavy than an equal bulk of water, being by this acceſſion made a little more heavy, muſt neceſſarily ſink; and the cauſe of its ſubmerſion, namely the preſſure of the oil, continuing, it muſt remain at the bottom.

AND to confirm this explication, I ſhall add, that in caſe, by inclining the tube or otherwiſe, you remove the cylinder of oil, or a competent part of it, (in caſe it were longer than was neceſſary) the bubble will again emerge to the top of the water (for, as for the oil, that is too light a liquor to buoy it up;) which happens only, becauſe the preſſure of the oil upon the water being taken off, the air, by virtue of its own ſpring, is able to recover its former expanſion, and reduce the bubble to be as light, as it was before.

AND now we may proceed to that other experiment, by which we lately promiſed to confirm the firſt paradox. And, in ſome regard, this following experiment has been preferred, as more ſtrange, to that I have been reciting; for it ſeemed much leſs improbable, that, of two heterogeneous liquors, the inferior ſhould be preſſed upon by the incumbent, which, though lighter, kept in an intire body above it; than that, in water, which is a homogeneous liquor, and whoſe parts mingle moſt freely and exquiſitely with one another, the upper part ſhould preſs upon the lower; and that they will do ſo, may appear by the experiment it is now time to ſubjoin.

PROVIDE a long tube, and a poiſed bubble, as in the former experiment; then, having poured water into the tube, till it reach above five or ſix inches (for a determinate height is no way neceſſary) above the bottom, caſt in the bubble, which will not only ſwim, but, if you thruſt it down into the water, it will of itſelf emerge to the upper part of it. Wherefore take a ſlender wand, or a wire, or a ſlender glaſs-pipe, or any ſuch body, that is long enough for your purpoſe, and, with it, having thruſt the bubble beneath the ſurface of the water, pour water ſlowly into the tube, (whoſe cavity will not be near filled by the rod, or wire,) till it have attained a competent height, (which, in my laſt trials, was about a foot, or half a yard above the bubble;) and you ſhall ſee, that the bubble, which before endeavoured to emerge, will, by the additional weight of the incumbent water, be depreſſed to the bottom of the tube. After which you may ſafely remove the wire, or other body, that kept it from riſing. For, as the weight of the incumbent water was that, which made it ſink, ſo, that weight continuing on it, the bubble will continue at the bottom.

BUT yet it is not without cauſe, that we employ a wire, or ſome ſuch thing, in this experiment, though we affirm it to be only the weight of the incumbent water, that makes the bubble ſink. For if you ſhould pour water into the tube to the height lately mentioned, or even to a greater, if you did not make uſe of the wire, it would not ſerve the turn; becauſe that, as faſt as you pour in the water, the bubble, being left to itſelf, will riſe together with it; and ſo, keeping always near the upper part of the water, it will never ſuffer the liquor to be ſo high above it, as it muſt be, before it can depreſs it. But to confirm, that it is the weight of the ſuperiour water, that ſinks the bubble, and keeps it at the bottom; if you take out of the tube a competent quantity of that liquor, and ſo take off the preſſure of it from the bubble, this will preſently, without any other help, begin to ſwim, and regain the upper part of the water; whence it may at pleaſure be precipitated, by pouring back into the tube the water, that was taken out of it. And theſe confirmations, added to the former proofs of the firſt and ſecond paradoxes, being, we conceive, ſufficient to ſatisfy impartial readers of the truth of them, we ſhould preſently advance to the next propoſition, if we did not think fit to interpoſe here a ſcholium.

SCHOLIUM.

IT may, perchance, be wondered at, why, ſince we lately mentioned our having made ſome trials with oil of tartar *per deliquium*, we did not, in the preſent experiment, inſtead of fair water, make uſe of that, it being a very much heavier liquor, and (though it may be incorporated with expreſſed oils) unmingleable, in ſuch trials, with oil of turpentine. But to this I anſwer; that, even in ſuch ſlender pipes, as thoſe made uſe of about the firſt experiment, I found, that oil of tartar was ponderous enough to flow down, though ſlowly, into the oil of turpentine at one ſide of the immerſed orifice, whilſt the oil paſſed upwards by it along the other ſide of the pipe. And my knowledge of this could not but make me a little wonder, that ſo curious a perſon, as Monſieur *Paſcal*, ſhould ſomewhere teach, that, if a tube of above fourteen foot long, and having its orifice placed fourteen foot under water, be full of quickſilver, the fluid metal will not all run out at the bottom of the pipe, though the top of it be left open to the air, but will be ſtopped at a foot high in the pipe. For the impetus, that its fall will give it, muſt probably make it flow quite out of the pipe: and, not here to mention thoſe trials of ours with quickſilver and ſlender tubes, that made me think this very improbable, if we conſider, that the experiment will not ſucceed, with much more favourable circumſtances, betwixt oil of turpentine and oil of tartar, though the heavier of theſe two liquors be many times lighter than quickſilver; it tempts me much to ſuſpect

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ſuſpect; that Monſieur *Paſcal* never actually made the experiment, at leaſt with a tube as big as his ſcheme would make one gueſs; but yet thought he might ſafely ſet it down, it being very conſequent to thoſe principles, of whoſe truth he was fully perſuaded. And indeed, were it not for the impetus, the quick-ſilver would acquire in falling from ſuch a height, the ratiocination were no way unworthy of him.

BUT experiments, that are but ſpeculatively true, ſhould be propoſed as ſuch, and may oftentimes fail in practice; becauſe there may intervene divers other things capable of making them miſcarry, which are overlooked by the ſpeculator, that is wont to compute only the conſequences of that particular thing, which he principally conſiders; as, in this caſe, our author ſeems not to have conſidered, that in ſuch tubes, as the Torricellian experiment is wont to be made in, the largeneſs of them would make them unfit for this trial.

AND I have known ingenious men, that are very well exerciſed in making ſuch experiments, complain, that they could never make this of Monſieur *Paſcal*'s to ſucceed. In which attempts, that the ſize of the tubes much contributed to the unſucceſsfulneſs of the trials, I ſhall, without repeating what has been already intimated to that purpoſe, in the following part of this diſcourſe have opportunity to manifeſt; and, withall, to add as illuſtrious a proof of this our ſecond paradox, as almoſt any we have yet given.

PARADOX III.

That if a body contiguous to the water be altogether, or in part, lower than the higheſt level of the ſaid water, the lower part of the body will be preſſed upwards by the water, that touches it beneath.

THIS may be proved by what has been already delivered in the explication of the firſt experiment: for, where-ever we conceive the loweſt part of the body, which is either totally, or in part, immerſed in water, to be, there the imaginary ſuperficies being beneath the true ſuperficies, every part of that imaginary ſuperficies muſt be preſſed upwards, by virtue of the weight of the water incumbent on all the other parts of the ſame ſurperficies; and ſo that part of it, on which the immerſed body chances to lean, muſt, for the ſame reaſon, have an endeavour upwards. And if that endeavour be ſtronger than that, wherewith the weight of the body tends downwards, then (ſuppoſing there be no accidental impediment) the body will be buoyed, or lifted up. And though the body be heavier than ſo much water, and conſequently will ſubſide, yet that endeavour upwards of the water, that touches its lower part, is only rendered ineffectual to the raiſing, or ſupporting the body, but not deſtroyed; the force of the heavy body being from time to time reſiſted, and retarded by the water, as much as it would be, if that body were put into one ſcale, and the weight of as much water, as is equal to it in bulk, were put into the other.

TO confirm this, we may have recourſe to what we ſaid in the explication of the ſecond experiment. For in caſe the ſlender pipe, wherein the water is kept ſuſpended, be thruſt deeper into the oil; or in caſe there be more oil poured into the veſſel, the water will be impelled up higher into the pipe; which it would not be, if the oil, though bulk for bulk a lighter body, did not preſs againſt the lower ſurface of the water, (where alone the two liquors are contiguous) more forcibly than the water, by its gravity, tends downwards. And, even when the liquors reſt in an æquilibrium, the oil continually preſſes upwards againſt the lower ſurface of the water; ſince in that continual endeavour upwards conſiſts its conſtant reſiſtance to the continual endeavour, that the gravity of the water gives it to deſcend. And ſince the ſame phænomenon happens, whether we ſuſpend water in oil, as in the ſecond experiment, or oil in water, as in the firſt; it appears, that the propoſition is as well applicable to thoſe caſes, where the ſuſtained body is ſpecifically heavier, as to thoſe, where it is ſpecifically lighter, than the ſubjacent fluid. *Fig.* I. II.

BUT a further and clearer proof of this doctrine will appear in the explication of the next propoſition. In the mean time, to confirm that part of our diſcourſe, where we mentioned the reſiſtance made by the water to bodies that ſink in it, let us ſuppoſe, in the annexed figure, that the pipe E F contains an oil ſpecifically heavier than water, (as are the oils of guaiacum, of cinnamon, or cloves, and ſome others;) and then, that the oil in the pipe, and the water without, being at reſt in an æquilibrium, the pipe be ſlowly raiſed towards the top of the veſſel: it is evident, from our former doctrine, and from experience too, that there will run out drops of oil, which will fall from the bottom of the pipe to that of the veſſel; but far more ſlowly, than if they fell out of the ſame pipe in the air. *Fig.* IV.

NOW, to compute, how much the preſſure of the water againſt the lower parts of the drop amounts to, let us ſuppoſe the drop to be G, to whoſe lowermoſt part there is contiguous, in any aſſignable place, where it falls, the imaginary ſuperficies H J. It is evident, that, if the drop of oil were not there, its place would be ſupplied by an equal bulk of water; which being of the ſame ſpecifick gravity with the reſt of the water in the veſſel, the ſurface H J would be laden every where alike; and conſequently no part of it would be diſplaced. But now, the drop of oil being heavier than ſo much water, that part of the imaginary ſuperficies, on which that drop leans, has more weight upon it, than any other equal part of the ſame ſuperficies; and conſequently will give place to the deſcending drop. And ſince the caſe of every other ſuppoſed ſurface, at which the drop can be conceived to arrive in its deſcent, will be the ſame with that of the ſuperficies H J; it will, for the reaſon newly given, continue falling, till

till it comes to the bottom of the Veſſel, which will ſuffer it to fall no further. And in caſe the drop G were not, as we ſuppoſe it, of a ſubſtance heavier *in ſpecie* than water, but juſt equal to it, the contiguous part of the ſuperficies H J would be neither more nor leſs charged, than the other parts of the ſame ſuperficies; and the part leaned on would be neither depreſſed nor raiſed, but the drop G would continue in the ſame place. And ſo we may prove, (what is affirmed by *Archimedes*, and other hydroſtatical writers) that a body, equiponderant *in ſpecie* to water, will reſt in any aſſignable place of the water where it is put.

AND (to proceed further) ſince if the drop G were of a matter but equiponderant to water, it would not ſink lower at all, no more than emerge; it follows, that though, being heavier *in ſpecie* than water, yet the gravity, upon whoſe account it falls, is no more than that, by which it ſurmounts an equal bulk of water; (ſince, if it were not for that overplus, the reſiſtance of the water would hinder it from falling at all:) and conſequently, it loſes in the water juſt as much of the weight it would have in the air, as ſo much water, weighed likewiſe in the ſame air, would amount to.

WHICH is a phyſical account of that grand theorem of the Hydroſtaticks, which I do not remember that I have ſeen made out in any printed book, both ſolidly and clearly; the learned *Stevinus* himſelf, to whom the later writers are wont to refer, having but an obſcure, and not phyſical, demonſtration of it.

AND, becauſe this theorem is not only very noble, but, as we elſewhere manifeſt, very uſeful, it will not be amiſs to add, that it may eaſily be confirmed by experiment.

FOR, if you take (for inſtance) a piece of lead, and hang it by a horſe-hair (that being ſuppoſed very near equiponderant to water) from one of the ſcales of an exact balance; and, when you have put a juſt counterpoiſe in the other ſcale, ſuffer the lead to ſink in a veſſel of water, till it be perfectly covered with it, but hangs freely in it, the counterpoiſe will very much preponderate. And, part of the counterpoiſe being taken out, till the balance be again reduced to an æquilibrium, you may eaſily, by ſubducting what you have taken out, and comparing it with the whole weight of the lead in the air, find what part of its weight it loſes in the water. And then, if you weigh any other piece of the ſame lead, ſuppoſe a lump of twelve ounces, and hang it by a horſe-hair at one ſcale, you may be ſure, that, by putting into the other ſcale a weight leſs by a twelfth part, (ſuppoſing lead to water to be, as twelve to one) that is, eleven ounces, though the weights be far from an æquilibrium in the air, they will be reduced to it when the lead is covered with water.

THE preſſure of water againſt the lower part of the body immerſed in it may be confirmed by adding, that we may thence deduce the cauſe of the emergency of wood, and other bodies lighter than water; which though a familiar effect, I have not found its cauſe to have been ſo much as inquired into by many, nor, perhaps, to have been well rendered by any. If we ſuppoſe then, that the pipe be almoſt filled, not with a ſinking, but a ſwimming oil, as oil of turpentine, if, as in the firſt experiment, the lower orifice be thruſt under water, (to a far leſs depth, than that of the oil in the pipe) and the upper be ſlowly unſtopped, the oil will, as we formerly declared, get out in drops at the bottom of the pipe. But to determine, why theſe drops, being quite covered and ſurrounded with water, and preſſed by it as well downwards as upwards, ſhould rather emerge than deſcend, I ſhall not content myſelf to ſay, that water *in ſpecie* is heavier than this kind of oil: for, beſides that, in ſome caſes, ere long to be mentioned, I have made the water to depreſs even this kind of oil, and beſides that, it is not every piece of wood, lighter *in ſpecie* than water, that will float upon water, how ſhallow ſoever it be; the queſtion is, how this prepollent gravity of the water comes to raiſe up the oil, though there be, perchance, much more water, for it to break its way thorough, above it, than beneath it.

THE reaſon then of the emerſion of lighter bodies in heavier fluids ſeems to be this, that the endeavour upwards of the water, contiguous to the lower part of the body, is ſtronger than the endeavour downwards of the ſame body, and the water incumbent on it. As, in the former ſcheme, ſuppoſing the drop G to be the oil of turpentine, and to touch the two imaginary and parallel plains H J, K L; it is evident, that upon the lower part of the drop N, there is a greater preſſure of water, than upon the upper part of the ſame drop, M: becauſe, that upon all the ſurface K L, there is but an uniform preſſure of water A K B L, and upon all the parts of the ſurface H I, there is a greater weight of water A H B I, except at the part N; for there the oil G, being not ſo heavy as ſo much water, the oil being expoſed to a greater preſſure from beneath, than its own gravity (and that of the water incumbent on it) will enable it to reſiſt, muſt neceſſarily give way, and be impelled upward. And the caſe being the ſame between that and any other parallel plain, whereſoever we ſuppoſe it to be in its aſcent, it muſt conſequently be impelled further and further upwards, till it arrive at the top; and there it will float upon the water. Or, (to explicate the matter without figures) when a ſpecifically lighter body is immerſed under water, it is preſſed againſt by two pillars of water; the one bearing againſt the upper, and the other againſt the lower part: and becauſe the lengths of both theſe pillars muſt be computed from the top of the water, the lower part of the immerſed body muſt be preſſed upon by a pillar longer than the upper part by the thickneſs of the immerſed body; and conſequently muſt be preſſed more upwards than downwards. And by how much the greater diſparity of ſpecifick gravity there is betwixt the

the water and the emerging body, by ſo much the ſwifter (*cæteris paribus*) it will aſcend: becauſe ſo much the more will there be of preſſure upon all the other imaginary ſurface, than upon that part, that happens to be contiguous to the bottom of the aſcending body.

AND upon the ſame grounds we may give (what we have not yet met with) a good ſolution of that problem, propoſed by hydroſtatical writers, Why, if a cylindrical ſtick be cut in two parts, the one as long again as the other, and both of them, having been detained under water at the ſame depth, be let go at the ſame time, and permitted to emerge, the greater will riſe faſter than the leſſer. For ſuppoſe one of theſe bodies, as O P, to be two foot high, and the other, Q R, to be half ſo much, and that the lowermoſt ſurfaces of both be in the ſame imaginary plain, parallel to the uppermoſt ſurface of the water, and three foot diſtant from it; in this caſe there will be againſt the lower part of each of the wooden bodies a preſſure, (from the laterally ſuperiour water) equal to that upon all the other parts of the imaginary plain, whereto thoſe bodies are contiguous. But whereas upon the upper ſurface of the ſhorter body, Q R, there will lean a pillar of water two foot high, the pillar of the ſame liquor, that will lean upon the top of the taller body, P O, will be but one foot high; as the attentive conſiderer will eaſily perceive. So that the wooden bodies being lighter *in ſpecie* than water, both of them will be impelled upwards; but that compounded pillar (if I may ſo call it) which conſiſts of one foot of wood, and two foot of water, will, by its gravity, more reſiſt the being raiſed, than that which conſiſts of two foot of wood, and but one foot of water: ſo that the cauſe of the unequal celerity in the aſcenſion of theſe bodies conſiſts chiefly, (for I would neither overvalue nor exclude concomitant cauſes) that the difference of the preſſure againſt the upper and lower part of each body reſpectively is greater in one than in the other.

AND hence we may probably deduce a reaſon of what we often obſerve in the diſtillation of the oils of aniſeeds, cloves, and divers aromatick vegetables, in lembecks, by the intervention of water: for oftentimes when the fire has not been well regulated, there will come over, beſides the floating oil, a whitiſh water, which will not in a long time become clear. And as we have elſewhere taught that whiteneſs to proceed from the numerous reflections from the oily ſubſtance of the concrete, by the heat of the fire broken into innumerable little globules, and diſperſed through the body of the water; ſo the reaſon, why this whiteneſs continues ſo long, ſeems to be chiefly (for I mention not ſuch things, as, the great ſurfaces, that theſe little globules have in reſpect of their bulk) that, becauſe of the exceeding minuteneſs of theſe drops, the height of the water, that preſſes upon the upper part, is almoſt equal to that of the water, that preſſes againſt the lower part. So that the difference between theſe two preſſures being inconſiderable, it has power to raiſe the drops but very ſlowly, (inſomuch, that upon this ground I deviſed a menſtruum, wherewith I could mingle oil in drops ſo exceedingly minute, that even when there were but a few ſpoonfuls of the mixture, it would continue whitiſh for divers whole days together) though at length they will emerge: and the ſooner, becauſe, whilſt they ſwim up and down, as they frequently chance to meet and run into one another, they compoſe greater drops; which are (for the reaſon already given) leſs ſlowly impelled up by the water; at the top of which, the chymiſt, after a due time, is wont to find new oil floating. But whether this be any way applicable to the ſwimming of the inſenſible particles of corroded metals in aqua-fortis, and other ſaline menſtruums, I muſt not now ſtay to inquire.

ONE thing more there is, that I would point at, before I diſmiſs this paradox; namely, that, for the ſame reaſon we have all this while deduced, when the emergent drop, or any other body, floats upon the top of the water, it will ſink juſt ſo far, (and no farther) till the immerſed part of the floating body be e- *Fig.* V.
qual in bulk to as much water as is equal in weight to the whole body. For ſuppoſe, in the annexed figure, Y to be a cube of wood three foot high, and ſix pound in weight; this wood, being much heavier than air, will ſink into the water, till it come to an imaginary ſuperficies, X W, where, having the poſition newly deſcribed, it will neceſſarily acquieſce. For all the other equal parts of the ſuperficies, X, W, Q, being leaned upon by pillars of water equal in height to the part X A, or W B, if the whole weight of the wooden cube be greater than that of as much water, as is equal to the immerſed part, it muſt neceſſarily ſink lower, becauſe the ſubjacent part of the ſurface (at V) will be more charged than any of the reſt. And, on the other ſide, if the cube were lighter than as much water as that, whoſe place the immerſed part takes up; it muſt, by the greater preſſure of the water upon the other parts of the imaginary ſuperficies, X W, than upon that contiguous to the wood, (as at V) be impelled upward, till the preſſure of the whole wood upon the part it leans on, be of the ſame degree with that of the reſt of the water, upon the reſt of the ſuperficies; and conſequently be the ſame with the water, whoſe place the immerſed part of it takes up; the lightneſs of that immerſed part, in reſpect of ſo much water, being recompenſed by the weight of the unimmerſed part, which is extant above the ſuperficies of the water. And we ſee, that when a piece of wood falls into water, though, by the impetus it acquires in falling, it paſſes through divers imaginary plains, that lie beneath its due ſtation; yet the greater preſſure, to which each of thoſe plains is expoſed in all its other parts, than in that, which is contiguous to the bottom of the wood, does quickly impel it up again, till, after ſome emerſions and ſubſidings, it reſts

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reſts at length in ſuch a poſition, as the newly explicated hydroſtatical theorem aſſigns it.

SCHOLIUM.

THIS ingenious propoſition (about floating bodies) is taught and proved, after the manner of mathematicians, by the moſt ſubtle *Archimedes*, and his commentators; and we have newly been endeavouring to manifeſt the phyſical reaſon, why it muſt be true. But partly becauſe the propoſition ought to hold, not only in ſuch intire and homogeneous bodies as men exemplify it in, (ſuch as a piece of wood, or a lump of wax) but in all bodies, though of a concave figure, and made up of many bodies of never ſo differing natures; (and perhaps ſome of them joined together only by their ſuperincumbency upon one another;) and partly, becauſe that a truth, which is one of the main and uſefulleſt of the Hydroſtaticks, and may be of ſo much importance to navigation, has not yet (that I know of) been attempted to be demonſtrated, otherwiſe than upon paper; it will not be amiſs, for the ſatisfaction of ſuch of thoſe, whom it may concern, as are not verſed in mathematical demonſtrations, to add an experiment, which I made to prove it mechanically, as exactly as is neceſſary for the ſatisfaction of ſuch perſons.

AFTER, then, having imployed ſeveral veſſels, ſome of wood, ſome of latten, and ſome of other materials, to compaſs what I deſired; we found glaſſes to be the moſt commodious we could procure. And therefore, filling a large and deep glaſs to a convenient height with fair water, we placed in it another deeper glaſs, ſhaped like a goblet or tumbler, that it might be the fitter for ſwimming; and having furniſhed it firſt with ballaſt, and then, for merriment ſake, with a wooden deck, by which a tall maſt, with a ſail faſtned to it, was kept upright; we fraughted with wood, and by degrees poured ſand into it, till we had made it ſink juſt to the tops of certain conſpicuous marks, that we had faſtned on the outſide of the glaſs, to oppoſite parts thereof. Then obſerving, how high the water reached in the larger glaſs, (which, by reaſon of the veſſel's tranſparency, was to be ſeen) we carefully placed two or three marks in the ſame level with the horizontal ſurface of the water; and taking out the floating veſſel as it was, with all that belonged to it, and wiping the outſide dry, we put it into a good pair of ſcales, and having found what it amounted to, we weighed in a competently large phial (firſt counterpoiſed apart) ſo much water, (to a grain, or thereabouts,) and pouring this water into the large glaſs above mentioned, we found it to reach to the marks, that we had faſtned to the outſide of the glaſs, and conſequently to reach to the ſame height, to which the weight of the floating glaſs, and all that was added to make it reſemble a ſhip, had made it ariſe to. By which experiment (which we tried, as to the eſſential parts of it, with veſſels of differing ſizes, ſhapes, and ladings too, as wood, ſtone, quickſilver, *&c.*) it appears, that the floating veſſel itſelf, with all that was in it, or ſupported by it, was equal in weight to as much water as was equal in bulk to that part of the veſſel, which was under water, ſuppoſed to be cut off from the extant part of the ſame veſſel, by a plain continuing the horizontal ſurface of the water: ſince the weight of the floating veſſel, which raiſed up the water in the larger veſſel to the greateſt height it attained, was the ſame with the weight of the water, which being poured into the larger veſſel (when the other was taken out) raiſed the water therein to the ſame height. We may alſo obtain the ſame end, by a ſomewhat differing way, (which is the beſt way, in caſe the veſſels be too great,) *viz.* to obſerve, firſt, by pouring in water out of a bowl or pail, or other veſſel of known capacity, as often as is neceſſary to fill the great veſſel, or ciſtern, or pond, to the top, (or to any determinate height required;) and, next, letting out, or otherwiſe removing all that water, to put in its place the veſſel, whoſe weight is to be found out. Thirdly, to let, or pour in water, till the veſſel be afloat, and by its weight raiſe the external water to the height it had before. And laſtly, to examine, how much this water, that was laſt poured in, falls ſhort in weight of the water, that was in it at firſt, and afterwards removed. For this difference will give us the weight of as much water, as is equiponderate to the whole floating veſſel, whether ſmall or great, with all that it either carries or ſuſtains. The hydroſtatical theorem we have been conſidering, and the experiments, whereby we have endeavoured to confirm or illuſtrate it, may (*mutatis mutandis*) be applied to a ſhip with all her ballaſt, lading, guns, and company; it holding generally true, *That* (to expreſs the ſenſe of the propoſition more briefly) ***the weight of a floating body is equal to as much water, as its immerſed part takes up the room of.*** Whence we might draw ſome arguments in favour of the learned *Stevinus*, (for whoſe ſake it partly was, that I annexed this ſcholium) who, if I miſremember not, does ſomewhere deduce as a corollary from certain hydroſtatical propoſitions, that a whole ſhip, and all that belongs to it, and leans upon it, preſſes no more nor leſs upon the bottom it ſwims over, than as much water, as is equal in bulk to that part of the ſhip, which is beneath the ſurface of the water.

See paradox the ſixth.

PARADOX IV.

That in the aſcenſion of water in pumps, &c. there needs nothing to raiſe the water, but a competent weight of an external fluid.

THIS propoſition may be eaſily enough deduced from the already mentioned experiments. But yet, for further illuſtration and proof, we will add that, which follows.

TAKE a ſlender glaſs-pipe, (ſuch as was uſed about the firſt experiment) and ſuck into it about the height of an inch of deeply tinged water; and, nimbly ſtopping the upper

per orifice, immerſe the lower part of the pipe into a glaſs half filled with ſuch tincted water, till the ſurface of the liquor in the pipe be an inch (or as low as you would have it) beneath that of the external water. Then pouring on oil of turpentine, till it ſwim three or four inches, or as high as you pleaſe above the water; looſen gently your finger from the upper orifice of the pipe, to give the incloſed air a little intercourſe with the external; and you ſhall ſee the tincted water in the pipe to be impelled up, not only higher than the ſurface of the external water, but almoſt as high as that of the external oil, through which (it being tranſparent and colourleſs) the red liquor may be eaſily diſcerned.

NOW in this caſe it cannot be pretended, that the aſcent of the water in the pipe proceeds from nature's abhorrency of a vacuum; ſince the pipe being full of air, and its orifice unſtopped, though the water ſhould not aſcend, no danger of a vacuum would enſue; the air and the water remaining contiguous as before.

THE true reaſon, then, of the aſcent of the water, in our caſe, is but this; that upon all the other parts of the imaginary ſuperficies, that paſſes by the immerſed orifice of the pipe, there is a preſſure partly of water, and partly of the oil ſwimming upon that water, amounting to the preſſure of four or five inches of water; whereas upon that part of the ſame ſuperficies, whereon the liquor contained in the pipe leans, there is but the preſſure of one inch of water: ſo that the parts near the immerſed orifice muſt neceſſarily be thruſt out of place by the other parts of water, that are more preſſed; till ſo much liquor be impelled up into the pipe, as makes the preſſure on that part of the imaginary ſuperficies as great, as that of the oil and water on any other equal part of it. And then, by virtue of the æquilibrium, (often mentioned) the water will riſe no further; and, by virtue of the ſame æquilibrium, it will reſt a little beneath the ſurface of the external oil, becauſe this laſt named liquor is leſs heavy, bulk for bulk, than water.

AND by this we may be aſſiſted to give a reaſon of the aſcenſion of water in ordinary ſucking pumps. For as the oil of turpentine, though a lighter liquor than water, and not mingleable with it, does, by leaning upon the ſurface of the external water, preſs up the water within the pipe, to a far greater height than that of the external water itſelf; ſo the air, which, though a far lighter liquor than oil of turpentine, reaches I know not how many miles high, leaning upon the ſurface of the water in a well, would preſs it up into the cylindrical cavity of the pump, much higher than the external water itſelf reaches in the well, if it were not hindered.

Now that, which hinders it in the pump, is either the ſucker, which fences the water in the pump from the preſſure of the external air, or that preſſure itſelf. And therefore, all that the drawing up of the ſucker needs to do, is, to free the water in the pipe from the impediment to its aſcent, which was given it by the ſucker's leaning on it, or the pillar of the atmoſphere's being incumbent on it; as in our experiment, the ſides of the pipe do ſufficiently protect the water in the pipe from any preſſure of the external oil, that may oppoſe its aſcent.

AND laſtly, as the water in our pipe was impelled up ſo high, and no higher, that the cylinder of water in the pipe was juſt able to balance the preſſure of the water and oil without the pipe; ſo in pumps, the water does riſe about thirty three or thirty four foot: and though you pump never ſo long, it will be raiſed no higher; becauſe at that height the preſſure of the water in the pump, upon that part of the imaginary ſuperficies, that paſſes by the lower orifice of it, is the ſame with the preſſure, which other parts of that imaginary ſuperficies ſuſtain from as much of the external water, and of the atmoſphere, as come to lean upon it.

THAT there may be caſes, wherein water may be raiſed by ſuction, not upon the account of the weight of the air, but of its ſpring, I have elſewhere ſhown; and having likewiſe in other places endeavoured to explicate more particularly the aſcenſion of water in pumps; what has been ſaid already may ſuffice to be ſaid in this place, where it is ſufficient for me to have ſhewn, that, whether or no the aſcenſion of water *may have* other cauſes, yet, in the caſes propoſed, it *needs* no more than the competent weight of an external fluid, as is the air; whoſe not being devoid of gravity, the cogency of our experiments has brought even our adverſaries to grant us.

FOR confirmation of this, I will here add, becauſe it now comes into my mind, (what might, perhaps, be elſewhere ſomewhat more properly mentioned) an experiment, that I did but lightly glance at in the explication of the firſt, and the ſcholium of the ſecond paradox.

IN order to this, I muſt advertiſe, that, whereas I there took notice, that ſome ingenious men had complained, that, contrary to the experiment propoſed by Monſieur *Paſcal*, they were not at all able to keep mercury ſuſpended in tubes, however very ſlender, though the lower end were deeply immerſed in water, if both their ends were open; the reaſons of my doubting, whether our ingenious author had ever made, or ſeen the experiment, were not only, that it had been unſucceſsfully tried, and ſeemed to me unlikely to ſucceed in tubes more ſlender, than his appeared; but, becauſe the impetus, which falling quickſilver gains by the acceleration of motion it acquires in its deſcent, muſt, in all probability, be great enough to make it all run out at the bottom of a tube open at both ends, and filled with ſo ponderous a liquor, though the tube were very much ſhorter, than that propoſed by Monſieur *Paſcal*.

THIS advertiſement I premiſe, to intimate, that, notwithſtanding the hopeleſſneſs of the experiment, as it had been propoſed and tried,

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tried, I might have reaſon not to think it impoſſible to perform, by another way, the main thing deſired; which was, to keep quickſilver ſuſpended in a tube, open at both ends, by the reſiſtance of the ſubjacent water. For, by the expedient I am going to propoſe, I have been able to do it, even with a liquor much lighter than water.

FINDING then, that even a very ſhort cylinder of ſo ponderous a fluid as mercury, would, if it were once in falling, deſcend with an impetus not eaſy to be reſiſted by the ſubjacent liquor, I thought upon the following expedient to prevent this inconvenience. I took a ſlender pipe, the diameter of whoſe cavity was little above the ſixth part of an inch; and having ſucked in, at the lower end of it, ſomewhat leſs than half an inch of quickſilver, and nimbly ſtopped the upper orifice with my finger, I thruſt the quickſilver into a deep glaſs of oil of turpentine, with a care not to unſtop the upper orifice, till the ſmall cylinder of quickſilver was eighteen or twenty times its depth beneath the ſurface of the oil. For by this means, when I unſtopped the pipe, the quickſilver needed not (as otherwiſe it would) begin to fall, as having a longer cylinder, than was requiſite to make an æquilibrium with the other fluid. For, by our expedient, the preſſure of the oil was already full as great, if not greater, againſt the lower part of the mercurial cylinder, as that, which the weight of ſo ſhort a cylinder could exerciſe upon the contiguous and ſubjacent oil. And accordingly, upon the removal of my finger, the quickſilver did not run out, but remain ſuſpended in the lower part of the pipe. And as, if I raiſed it towards the ſuperficies of the oil, the mercury would drop out for want of its wonted counterpoiſe; ſo, if I thruſt the pipe deeper into the oil, the increaſed preſſure of the oil would proportionably impel up the mercury towards the higher parts of the pipe; which being again a little, and but a little, raiſed, the quickſilver would fall down a little nearer the bottom of the pipe: and ſo, with a not unpleaſant ſpectacle, the ponderous body of quickſilver was made ſometimes to riſe, and ſometimes to fall; but ſtill to float upon the ſurface of a liquor lighter than common ſpirit of wine itſelf.

BUT, beſides that the experiment, if the maker of it be not very careful, may eaſily enough miſcarry, the divertiſement it gives ſeldom proves laſting; the oil of turpentine, after a while, inſinuating itſelf betwixt the ſides of the pipe and thoſe of ſo ſhort a cylinder of mercury, and thereby diſordering all. And therefore, though I here mention this experiment, as I tried it in oil of turpentine, becauſe that is the liquor I make uſe of all along theſe paradoxes; and becauſe alſo I would ſhew, that a lighter fluid than water (and therefore why not air, if its height be greatly enough increaſed?) may, by its weight and preſſure, either keep the mercury ſuſpended in pipes, or even raiſe it in them: yet I found water, wherewith I filled tall glaſſes, a fitter liquor than oil for the experiment, in which though I ſought, and found ſome other phænomena; yet, becauſe they more properly belong to another place, I ſhall leave them unmentioned in this.

AND ſince experience ſhews us, that a cylinder of mercury, of about thirty inches high, is equiponderant to a cylinder of water of about thirty-three, or thirty-four foot high; it is very eaſy to conclude, that the weight of the external air, which is able to raiſe and keep ſuſpended thirty-three, or thirty-four foot of water in a pump, may do the like to twenty-nine, or thirty inches of quickſilver in the Torricellian experiment.

PARADOX V.

That the preſſure of an external fluid is able to keep an heterogeneous liquor ſuſpended at the ſame height in ſeveral pipes, though thoſe pipes be of very different diameters.

THE contrary of this propoſition is ſo confidently aſſerted and believed by thoſe mathematicians and others, that favour the doctrine of the ſchools, that this perſuaſion of theirs ſeems to be the chief thing, that has hindered men from acknowledging, that the quickſilver, in the Torricellian experiment, may be kept ſuſpended by the counterpoiſe of the external air. And a famous writer, that has lately treated, as well of the Hydroſtaticks, as of the phænomena of the Torricellian experiment, does rely ſo much upon the falſhood of our paradox, that, laying aſide all other arguments, he contents himſelf to confute his adverſaries with one demonſtration (as he calls it) grounded on the quite contrary of what we here aſſert. For his objection runs to this ſenſe; That, if it were the preſſure of the external air, that kept the quickſilver ſuſpended in the newly-mentioned experiment, the height would not (as experience ſhews it is) be the ſame in all cylindrical pipes, though of very differing bores. For, ſuppoſing the height of the mercurial cylinder, in a tube of half an inch diameter, to be twenty-nine inches; it is plain, that a mercurial cylinder of the ſame height, and three inches in diameter, muſt weigh divers times as much as the former: and therefore the preſſure of the external air being but one and the ſame, if it be a juſt counterpoiſe to the greater cylinder, it cannot be ſo to the leſs; and if it be able to keep the one ſuſpended at twenty-nine inches, it muſt be able to keep the other ſuſpended at a far greater height; which yet is contrary to experience. And indeed this objection is ſo ſpecious, that, though I elſewhere have already anſwered it, both by reaſon and experience, as far forth as it concerns the Torricellian experiment; yet, to ſhew the miſtake, on which it is grounded, it may be very well worth while to make out our propoſed paradox, (as that, whoſe truth will ſufficiently diſprove that error) by ſhewing, both *that* the aſſertion is true, and *why* it muſt be ſo.

PROVIDE, then, a more than ordinarily wide-mouthed glaſs, clear, and of a convenient depth; *Fig.* VI.

depth; into which having put a convenient quantity of water, deeply tinged with brazil, or ſome other pigment, fit to the orifice a broad but thin cork, in which, by burning or cutting, make divers round holes of very differing wideneſſes; into each of which you may thruſt a glaſs cylinder, open at both ends, and of a ſize fit for the hole, that is to receive it, that ſo the ſeveral pipes may be embraced by theſe ſeveral holes; and, as near as you can, make them parallel to one another, and perpendicular to the ſuperficies of the water, into which they are to be immerſed. But we muſt not forget, that, beſides theſe holes, there is an aperture to be made in the ſame cork (it matters not much of what figure, or whereabouts) to receive the ſlender end of a glaſs funnel; by which oil may be conveyed into the veſſel, when it is ſtopped with the cork. And in the ſlender part of this funnel we uſe to put ſome cotton-wick, to break the violence of the oil, that is to be poured in, which might elſe diſorder the experiment. All this being thus provided, and the cork (furniſhed with its pipes) being fitted to the orifice of the veſſel; if at the funnel you pour in oil of turpentine, and place the glaſs betwixt your eye and the light, you may, through that tranſparent liquor, perceive the tincted water to be impelled up into all the pipes, and to riſe uniformly in them. And, when this tincted liquor has attained to the height of two or three, or more inches, above the lowermoſt ſurface of the external oil, if you remove the funnel, (which yet you need not do, unleſs there be yet oil in it) you may plainly perceive the water to reach as high in one of the ſmaller pipes, as in another three or four times as great; and yet the water in the ſeveral pipes, as it is evident, is ſuſtained at that height above the level of the other water, by the preſſure or counterpoiſe of the external oil; which therefore, being lighter *in ſpecie* than water, will have its ſurface ſomewhat higher without the pipes, than that of the tincted water within them. And if by the aperture, that receives the funnel, you immerſe, almoſt to the bottom of the oil, the ſhorter leg of a ſlender glaſs ſiphon, at whoſe longer leg you procure by ſuction the oil to run out; you ſhall perceive, that, according as the depth and preſſure of the external fluid decreaſes, ſo the water in the pipe will ſubſide; and that uniformly, as well in the leſſer, as in the greater pipes.

THE reaſon of this is not difficult to be rendered by the doctrine already delivered. For, ſuppoſe EF to be the ſurface of the water, both within and without the pipes, before any oil was poured on it: if we then ſuppoſe the oil to be poured in through the funnel, its lightneſs in reſpect of water, wherewith it will not mingle, will keep it from getting into the cavity of the pipes L, M, N; and therefore, ſpreading itſelf on the outſide of them above, it muſt neceſſarily, by its gravity, preſs down the ſuperficies of the external water, and impel up that liquor into the cavities of the pipes. And if we ſuppoſe the pouring on of the oil to be continued, till the uppermoſt ſurface of the oil be raiſed to GH, and that of the external water depreſſed to IK, (or thereabouts) an imaginary plane paſſing along the lower orifices of the pipes; I ſay, the tincted waters in the pipes ought to have their uppermoſt ſurfaces in the ſame level, notwithſtanding the great inequality of their bores. For that part of the ſurface IK, which is comprehended within the circular orifice of the greateſt pipe L, is no more charged by the incumbent water, than any other part, equal to that circle of the ſame imaginary ſuperficies, is by the water or oil incumbent on it; (and conſequently, no more than the part, comprehended within the circle of the ſmall pipe N, is by the water contained in that ſmall pipe;) the external oil having as much a greater height upon the ſuperficies IK, than the water within the pipe, as is requiſite to make the two liquors counterbalance each other, notwithſtanding the difference of their ſpecifick gravities. And though the pipe L were twice as big, it would charge the ſubjacent plane IK no more, than the preſſure of the oil on the other parts of the ſame imaginary ſurface is able to reſiſt. And yet this preſſure of the external oil ought not to be able to raiſe the water in the ſlender pipe N higher, than the ſurface Q in the ſame level with the ſurface O. For, if the water were higher in the ſmall pipe, being a heavier liquor than oil, it muſt preſs upon that part of the ſurface IK, it leans on, with greater force, than the external oil upon the other parts of the ſame plane IK; and therefore with greater force, than the weight of the external oil could reſiſt. And, conſequently, the water in the ſlender pipe muſt ſubſide, till its ſurface be inferiour to that of the external oil; ſince, till then, the difference of their ſpecifick gravities cannot permit them to reſt in an æquilibrium. To be ſhort; it is all one to the reſiſtance of the external oil, how wide the cylinder is, that it ſupports in the pipe; provided the height of it be not greater, in reſpect of the height of the oil, than the difference of the reſpective gravities of thoſe two liquors requires. For, ſo long the preſſure of the cylinder of water will be no greater on that part of the imaginary ſuperficies, which it leans upon, than the preſſure of the external oil will be on all the other parts of the ſame ſuperficies; and conſequently, neither the one, nor the other of thoſe liquors will ſubſide, but they will both reſt in an æquilibrium.

BUT here it will not be amiſs to note, firſt, that it is not neceſſary, that the glaſs cylinders L, M, N, ſhould be all of the ſame length; ſince, the lower orifice being open, the water will riſe to the ſame height within them, whether the parts immerſed under the water be exactly of the ſame length, or no.

AND ſecondly, That throughout all this diſcourſe, and particularly in the explication of this paradox, we ſuppoſe, either that the ſlendereſt pipes, that are employed about theſe experiments, are of a moderate ſize, and not exceeding ſmall; or that, in caſe they be very

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very ſmall, allowance be made in ſuch pipes for this property, that water will riſe in them to a greater height, than can be attributed to the bare counterpoiſe of either the water, or the oil, that impels it upwards, and keeps it ſuſpended. But this difference is of ſo little moment in our preſent inquiries, that we may ſafely neglect it, (as hereafter we mean to do) now we have taken this notice of it for prevention of miſtakes.

PARADOX VI.

If a body be placed under water, with its uppermoſt ſurface parallel to the horizon; how much water ſoever there may be on this, or that ſide above the body, the direct preſſure, ſuſtained by the body, (for we now conſider not the lateral, nor the recoiling preſſure, to which the body may be expoſed, if quite environed with water,) is no more, than that of a column of water, having the horizontal ſuperficies of the body for its baſis, and the perpendicular depth of the water for its height.

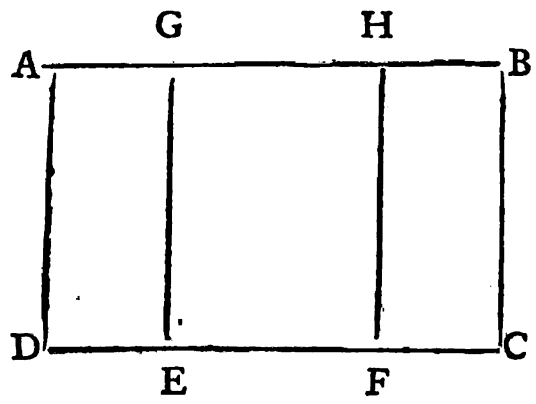
And ſo likewiſe,

If the water, that leans upon the body, be contained in pipes open at both ends, the preſſure of the water is to be eſtimated by the weight of a pillar of water, whoſe baſis is equal to the lower orifice of the pipe, (which we ſuppoſe to be parallel to the horizon,) and its height equal to a perpendicular reaching thence to the top of the water; though the pipe be much inclined towards the horizon, or though it be irregularly ſhaped, and much broader in ſome parts, than the ſaid orifice.

STEVINUS, in the tenth propoſition of his Hydroſtatical Elements, having propoſed in more general terms the former part of our paradox, annexes to it a demonſtration to this purpoſe:

HAVING firſt ſuppoſed ABCD to be a ſolid rectangular figure of water, whoſe baſis EF is parallel to the horizon, and whoſe height GE is a perpendicular let fall from the uppermoſt ſurface of the water to the lowermoſt; his demonſtration is this:

Fig. VII.



IF the bottom EF be charged with a greater weight, than that of the water GHFE, that ſurpluſage muſt come from the adjoining water: therefore, if it be poſſible, let it be from the water AGED, and HBCF; which granted, the bottom DE will likewiſe have a greater weight incumbent on it, upon the ſcore of the neighbouring water GHFE, than that of the water AGED. And, the reaſon being the ſame in all the three caſes, the baſis FC muſt ſuſtain a greater weight, than that of the water HBCF: and therefore the whole bottom DC will have a greater weight incumbent on it, than that of the whole water ABCD; which yet (ABCD being a rectangular body) would be abſurd. And by the ſame way of reaſoning you may evince, that the bottom EF ſuſtains no leſs a weight, than that of the water GHFE. And ſo, ſince it ſuſtains neither a greater weight, nor a leſs, it muſt ſuſtain juſt as much weight, as the column of water GHFE.

THIS demonſtration of the learned *Stevinus* may well enough be admitted by a naturaliſt, (though, according to ſome hypotheſes touching the cauſe and nature of gravity, it may fail of mathematical exactneſs;) and by it may be confirmed the firſt part of our propoſed paradox. And ſome things, annexed by *Stevinus* to this demonſtration, may be alſo applied to countenance the ſecond. But, becauſe this is one of the nobleſt and uſefulleſt ſubjects of the Hydroſtaticks, we think it worth while to illuſtrate, after our manner, each of the two parts of our paradox by a ſenſible experiment.

FIRST then, take a ſlender glaſs pipe, of an even bore, turned up at one end like the annexed ſiphon. Into this ſiphon ſuck oil of turpentine, till the liquor have filled the ſhorter leg, and be raiſed two or three inches in the longer. Then, nimbly ſtopping the upper orifice with your finger, thruſt the lower part of the ſiphon ſo far into a deep glaſs full of water, that the ſurface of the oil in the longer leg of the pipe may be but a little higher than that of the external water; and, upon the removal of your finger, you will find the ſurface of the oil to vary but little, or not at all, its former ſtation. And as, if you then thruſt the pipe a little deeper, you will ſee the oil in the ſhorter leg to begin to be depreſſed; ſo, if afterwards you gently raiſe the pipe toward the top of the water, you ſhall ſee the oil not only regain its former ſtation, but flow out by degrees in drops, that will emerge to the top of the water. Now, ſince the water was able, at firſt, to keep the oil in the longer leg of the pipe ſuſpended no higher, than it would have been kept by a cylinder of water equal to the orifice of the ſhorter leg of the pipe, and reaching directly thence to the top of the water; (as may be eaſily tried, by making a ſiphon, where the ſhorter leg may be long enough to contain ſuch a cylinder of water to counterpoiſe the oil in the longer;) and ſince, when once, by the raiſing of the pipe, the height of the incumbent water was leſſened, the oil did more than counterbalance it, (as appears by its flowing out of the ſiphon;) we may well conclude, that, though there were in the veſſel a great deal of water, higher than the immerſed orifice of the ſiphon, (and it would be all one, though the ſiphon were placed at the ſame depth in a pond or lake;) yet, of all that water, no more did gravitate upon the orifice, than that, which was placed directly over it; which was

Fig. VIII.

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ſuch a pillar of water, as the paradox deſcribes.

AND, by the way, we may hence learn, that though water be not included in pipes, yet it may preſs as regularly upon a ſubjacent body, as if it were. And therefore we may well enough conceive a pillar of water, in the free water itſelf, where there is nothing on any ſide, but the contiguous water, to bound the imaginary pillar.

BUT I had forgot to add, that the firſt part of our paradox will hold, not only when the water, ſuperior to the body it preſſes upon, is free; but alſo, when it is included in veſſels of never ſo (ſeemingly) diſadvantageous a ſhape. For, if you ſo frame the ſhorter leg of a ſiphon, that it may expand itſelf into a funnel, like that of *fig.* 6. imployed about the proof of the foregoing (fifth) paradox; (for which purpoſe the legs muſt be at a pretty diſtance from each other:) though you fill that funnel with water, the oil in the longer and ſlender leg of the ſiphon will be able to reſiſt the preſſure of all the water, notwithſtanding the breadth of the upper part of the funnel. So that, even in this caſe alſo, the ſurface of the oil in the longer leg will be but a little higher than that of the water in the funnel.

FOR further confirmation of this, we cauſed to be made a ſiphon, ſo ſhaped, that one of the legs (which were parallel, and of the ſame bore,) had in the midſt of it a ſphere of glaſs, ſave that it communicated with the upper and lower parts of the ſame leg.

IN the uniform leg of the ſiphon, we put a convenient quantity of oil of turpentine, and into the other as much water, as filled not only the lower part of it, but the globular part too. And yet we did not find, that all this water was able to keep up the oil in the uniform leg, at a greater height, than if the leg, that contained the water, had been uniform too; as much of the water in the globe, as was not directly over the lower orifice of it, being ſupported by the lateral parts (if I may ſo call them) of the ſame globe. And if that leg were, inſtead of water, filled with oil, and the uniform leg with water; notwithſtanding the far greater quantity of oil, that was neceſſary to fill that leg, whereof the hollow ſphere was but a part; the water in the uniform leg would not be kept up, ſo much as to the ſame height with the oil in the miſhapen leg.

BUT to make this matter yet the more clear, we cauſed a ſiphon to be made of the
Fig. IX. figure expreſſed in the adjoining ſcheme; into which having poured a convenient quantity of mercury, till it reached in the ſhorter leg C D, almoſt to the bottom of the globulous part E, and in the longer leg A B, to an equal height: we afterwards poured a ſufficient quantity of water into the ſaid longer leg A B, which drove away the quickſilver, and impelled it up in the ſhorter leg till it had half, or more than half, filled the cavity of the globular part E; (which yet we did not wholly fill with quickſilver, becauſe the tube A B was not long enough for that purpoſe:) and then we obſerved, that, notwithſtanding the great weight of (that body, which is of all bodies, ſave one, the moſt ponderous) quickſilver, which was contained in the lower part of the ſame leg of the ſiphon, the ſurface of the quickſilver H G, was impelled up as high by the water in the leg A B, as the diſparity of the ſpecifick weights of thoſe two liquors (whereof one is about fourteen times as heavy as the other) did require: ſo that it appeared not, that, for all the great weight of quickſilver, contained in the globulous cavity E, there preſſed any more upon the ſlender and ſubjacent part E C of that leg, than as much as was placed directly over the lower orifice of the ſaid cavity E. So that the other, and lateral parts of that mercury being ſupported by the concave ſides of the glaſs, whereunto they were contiguous, the water in the leg A B appeared not any more preſſed by the quickſilver, than if the leg C D had been, as well as the other, of an uniform bigneſs; and, by this means, if we had made the hollow globe of a large diameter, a ſmall quantity of water, poured into the leg A B, might have been able to raiſe a quantity of quickſilver exceedingly much heavier than itſelf. But then ſo little water can raiſe the quickſilver, in ſo broad a pipe, but to an inconſiderable height.

TO make out the ſecond part of our paradox by an experiment, we took three glaſs-pipes; the one made like a bolt-head, with a round ball, and two oppoſite ſtems; the *Fig.* X. other was an irregular pipe, blown with an elbow, wherewith it made an angle; and the third was as irregularly ſhaped, as I could get it blown; being in ſome places much broader, and in ſome much narrower than the lower orifice of it. And theſe two laſt named pipes had their upper ends ſo inſerted into holes, made fit for them in a broad piece of cork; that, when they were immerſed, they made not right angles, but very oblique ones, with the horizontal ſurface of the liquor. The other glaſs likewiſe, which conſiſted of a great bubble, and two oppoſite pipes, was faſtned to the ſame cork, which having beforehand been made fit for a wide-mouthed glaſs of a good depth, and half filled with water, was thruſt as a ſtopple into the mouth of the ſaid glaſs, ſo that the water aſcended a pretty way into each of the three pipes by their lower orifices, which, as well as the upper, we left open; then a good quantity of oil of turpentine being poured into the ſame veſſel through a funnel, the water was by the incumbent oil impelled up to the height of two or three inches in each of the three pipes. Which argues, that, notwithſtanding their being ſo unequal in bigneſs, and ſo irregular in ſhape, (inſomuch that we gueſſed one of them was ten or twelve times greater in one part, than in another, or than it was even at the orifice) the water, contained in each of them, preſſed upon its lower orifice no more (I do not add, nor no leſs) than it would have done, if it had been

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a cylinder, having the orifice for its baſis, and the perpendicular depth of the water and oil above, for its height. For in caſe each of the pipes had contained but ſuch a cylinder of water, that water would nevertheleſs have had its uppermoſt ſuperficies at the ſame height: and, on the other ſide, it would have been impelled up beyond it, if its weight did not as ſtrongly endeavour to depreſs the immediately ſubjacent water, as the preſſure of the external fluids endeavoured to impel it up.

AND ſince the height of the water was about the ſame in the ſeveral pipes, though two of them, being very much inclined, contained much more water than if they were erected; yet by the ſame way of reaſoning we may gather, that the imaginary plain, paſſing by the immerſed orifice of either of theſe inclining pipes, ſuſtained no more of preſſure, than it would have done from a ſhorter cylinder of water, if erected. And indeed, in all theſe caſes, where a pipe either is broader in other places than at its lower orifice, or inclined any way towards the horizon, the weight of the contained liquor is not all ſupported by the liquor, or the body contiguous to the lower orifice, but partly by the ſides of the pipe itſelf. And therefore if, when in a ſlender pipe you have brought a parcel of oil of turpentine to be in an æquilibrium with the external water, as in the experiment belonging to the firſt paradox; if, I ſay, when this is done, you incline the pipe towards the ſides of the glaſs, you may indeed obſerve the ſurface of the oil in the pipe to be, as before, a little higher than that of the water without it: but you ſhall likewiſe ſee, that though the orifice of the pipe were not thruſt deeper into the water, yet there will be a pretty deal of water got up into the pipe; becauſe the oil not leaning now upon the water only, as it did before, but partly upon the water, and partly upon the pipe, its preſſure upon the ſubjacent water is conſiderably leſſened; and thereby the external water, whoſe preſſure is not diminiſhed too, is able to impel up the oil, and intrude for a little way into the pipe. But if you re-erect the pipe, the preſſure of the oil being then again exerted upon the ſubjacent water, it will be able to depreſs, and drive it again out of the cavity of the pipe.

AND to this agrees very well what we further tried as follows: We cauſed three pipes to be blown (ſhaped as the adjoining figures;) one having in it divers acute angles; the other being of a winding form, like a ſkrew or worm of the limbeck; and the third very irregularly crooked; and yet each of theſe pipes having all its crooked parts, and ſome of its ſtreight and erected parts, filled with oil of turpentine; being thruſt to a convenient depth under water and unſtopped there, (after the manner already often declared) we found, that, according to our paradox, the ſurface of the oil in the pipe was higher than that of the water without it, as much as it would have been in caſe the pipe had been ſtreight, (as we tried, by placing by the crookedeſt of them a ſtreight pipe with oil in it) though the quantity of the oil, in one of theſe pipes, were perhaps three times as much as would have ſufficed, if the pipe had been ſtrait: ſo that this ſurpluſage of oil did not preſs upon the ſubjacent water, (for if it had done ſo, the oil would have run out of the pipe.) And I remember, that lifting up as much of one of theſe crooked pipes, as I thought fit, ſomewhat above the ſurface of the water; when the ſuperficies of the oil in the pipe was not above half an inch higher than that of the water without it, I eſtimated, that the crooked pillar of oil, contained in that part of the pipe, which was above the ſurface of the water, was about ſeven or eight inches long. So true it is, that the preſſure of liquors, contained in pipes, muſt be computed by the perpendicular that meaſures their height, whatever be their length or bigneſs.

Fig. XI.

SCHOLIUM.

THE learned *Stevinus*, having demonſtrated the propoſition we lately mentioned out of him, ſubjoins divers conſectaries, of which the truth hath been thought more queſtionable, than that of the theorem itſelf. And therefore he thought fit to add a kind of appendix to make good a paradox, which ſeems to amount to this; that if, in the cover of a large cylindrical box, exactly cloſed, there be perpendicularly erected a cylindrical pipe open at both ends, and reaching to the cavity of the box; this inſtrument being filled with water, the circular baſis of it will ſuſtain a preſſure, equal to that of the breadth of the baſis and height of the pipe.

I CHOSE thus to expreſs this theorem, (which might be, according to *Stevinus*, propoſed in more general terms) becauſe this way of expreſſing it will beſt ſuit with the ſubſequent experiment, and may conſequently facilitate the underſtanding of the paradox. But though the learned *Stevinus*'s aims were to be commended; who finding this propoſition doubted, ſeems to have had a great mind to give an experimental demonſtration of it, and therefore propoſes no leſs than five pragmatical examples (as he calls them) to make out the truth of what he aſſerts; yet in this he hath been ſomewhat unhappy, that that experiment, which alone (for ought I can find) has been tried of all the five, is rejected as incompetent by thoſe, that profeſs to have purpoſely made trial of it. And indeed, by reaſon of the difficulty of bringing them to a practical examen, I have ſomewhat doubted, whether or no this uſeful writer did ever make all thoſe trials himſelf; rather than ſet down the events, he ſuppoſed they muſt needs have, as preſuming his conjectures rightly deduced from a demonſtrative truth. Wherefore though another of the experiments, he propoſes, be not free from difficulty, yet having, by the help of an expedient, made it practicable, we are induced by its plainneſs and clear-

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clearneſs to prefer it to what elſe he propoſes to the ſame purpoſe.

See Fig. XII. WE provided then a veſſel of latten, of the figure expreſſed in the ſcheme, and furniſhed it with a looſe bottom C D, made of a flat piece of wood covered with a ſoft bladder, and greaſed on the lower ſide near the edges, that leaning on the rim of wood G H, contiguous every where to the inſide of the latten, it might be eaſily lifted from off this rim; and yet lie ſo cloſe upon it, that the water ſhould not be able to get out between them: and to the midſt of this looſe bottom was faſtned a long ſtring, of a good ſtrength, for the uſe hereafter to be declared. The inſtrument thus fitted, the water was poured in apace at the top A B, which, by its weight preſſing the falſe bottom C D againſt the ſubjacent rim G H, contributed to make the veſſel the more tight, and to hinder its own paſſing. The veſſel being filled with water, we took the forementioned ſtring, one of whoſe ends was faſtned to I, the middle part of the looſe bottom, and, tying the other end K to the extremity of the beam of a good pair of ſcales, we put weights one after another into the oppoſite ſcale, till at length thoſe weights lifted up the falſe bottom C D from the rim G H; and conſequently lifted up the incumbent water; which preſently after ran down between them. And having formerly, before we poured in any water, tried what water would ſuffice to raiſe the bottom C D, when there was nothing but its own proper weight, that was to be ſurmounted; we found, by deducting that weight from the weight in the ſcale, and comparing the reſidue with the weight of as much water as the cavity of the broad, but very ſhallow cylinder, B E C H G D F, would have alone (if there had been no water in the pipe A I) amounted to; we found, I ſay, by comparing theſe particulars, that the preſſure upon C D was by ſo very great odds more, than could have been attributed to the weight of ſo little water, as the inſtrument pipe and all contained, in caſe the water had been in an uniform cylinder, and conſequently a very ſhallow one, of a baſis as large as that of our inſtrument; that we could not but look upon the ſucceſs, as that, which, though it did not anſwer what the reading of *Stevinus* might make a man expect; yet may deſerve to be further proſecuted, that whether or no the paradox of *Stevinus* (which not only ſome others, but the learned Dr. *Wallis* himſelf queſtion) will hold, the inquiry he has ſtarted, may be ſo perſued, as to occaſion ſome improvement of this part of Hydroſtaticks: where, to define things with certainty, will perhaps be found a difficulter taſk than at firſt glance one would think; both becauſe divers ſpeculative things muſt be taken into conſideration, whoſe theory has not perhaps yet been cleared, and becauſe of the difficulty, that will be found in practice by them, that ſhall go about to make *Stevinus*'s experiments, or others of that ſort, with all requiſite accurateneſs. As indeed, it is far eaſier to propoſe experiments, which would in likelihood prove what we intend, in caſe they could be made, than to propoſe practicable expedients, how they may be made.

PARADOX VII.

That a body immerſed in a fluid ſuſtains a lateral preſſure from the fluid; and that increaſed, as the depth of the immerſed body, beneath the ſurface of the fluid, increaſeth.

THOUGH I ſhall not wonder, if this propoſition ſeems ſtrange enough to moſt readers; yet I think I could make it out by ſeveral ways, and particularly by one, that is plain and eaſy, being but that which follows:

TAKE then a ſlender glaſs-pipe (like that imployed about the firſt experiment;) and cauſe it to be bent within two or three inches of one end, ſo that the longer and the ſhorter legs, E F and F G, may make, as near as can be, a right angle at F; then dipping the orifice of the ſhorter leg F G in oil of turpentine, ſuck into the ſiphon (if I may ſo call it) as much of the liquor as will fill the ſhorter leg, and reach two or three inches high in the longer: then nimbly ſtopping the upper orifice with your finger, immerſe the lower part of the glaſs under water, in ſuch manner, as that the longer leg E F may make, as to ſenſe, right angles with (A B) the horizontal ſurface of the water; and the ſhorter leg F G may be ſo far depreſſed under that ſurface, that I K, the ſuperficies of the oil in the longer leg, be but a little higher than A B, that of the external water. Then, removing your finger, you may obſerve, that the oil in the ſiphon will continue (with little or no change) in its former ſtation. By which it appears, that there is a lateral preſſure of the water againſt the oil contiguous to G, the orifice of the ſhorter leg of the pipe; ſince it is only that preſſure, that hinders the efflux of the oil at that orifice, notwithſtanding the preſſure of the perpendicular cylinder of oil, that would drive it out. *Fig.* XIII.

AND that this preſſure of the perpendicular cylinder doth really urge the oil in the ſhorter leg to flow out, you may learn, by ſlowly lifting the ſiphon (without changing its former poſture) towards the ſurface of the water. For as the lower leg comes nearer and nearer to that ſurface, (to which, as I newly intimated, it is ſtill to be kept parallel) the oil in the horizontal leg will be driven out in drops, by the preſſure of the other oil in the perpendicular leg.

THAT likewiſe, before you begin to raiſe the ſiphon, the lateral preſſure of the water againſt the lower orifice of it is, at leaſt in ſuch experiments, near about the ſame with what would be the perpendicular preſſure of a cylinder of water, reaching from the ſame orifice G (or ſome part of it) to the top of the water, may be gathered from hence, that the ſurface of the oil in the longer leg will be a little higher than that of the external water, as (by reaſon of the often mentioned comparative levity of the oil) it would be, if we ſuppoſe, that a pipe of glaſs of the

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ſame bore, and reaching to the top of the water, being fitted to the orifice of the horizontal leg (as in the annexed figure the cylinder, G H) were filled with water.

AND, to make out the latter part of our propoſition, we need add no more, than that, if you plunge the ſiphon deeper into the water, you ſhall find the oil, by the lateral preſſure of the water, driven by degrees quite out of the ſhorter leg into the longer: and if you thruſt it yet deeper, you may obſerve, that the longer leg will admit a cylinder of water, upon which that of oil will ſwim; the whole oil alone being unable to counterbalance the lateral preſſure of the water at ſo great a depth.

BY which laſt circumſtance, it appears, that water has alſo a lateral preſſure againſt water itſelf, and that increaſed according to its depth; ſince otherwiſe the external water could not impel that in the horizontal leg of the ſiphon into the perpendicular leg, though, to do ſo, it muſt ſurmount the weight or reſiſtance of the whole cylinder of oil, that muſt be here violently raiſed in the ſaid perpendicular leg.

BUT if you gently raiſe the ſiphon again, the lateral preſſure of the water againſt the immerſed orifice being diminiſhed, (according as the diſtance of that orifice G from the horizontal ſurface, A B, comes to be leſſened,) the prevalent oil will drive out the water, firſt out of the longer leg, and then out of the ſhorter, and will at length flow out in drops at the immerſed orifice, and thence emerge to the top of the water.

BESIDES, when the oil in the ſiphon does juſt counterbalance the external water, if you keep the ſhorter leg parallel to the ſurface of the water, and move the orifice of it this way or that way, and place it nearer or further off from the middle or from the ſides of the glaſs, (provided you keep it always at the ſame depth under the water) you will find the oil in the longer leg to continue (as to ſenſe) at the ſame height. Whence we may learn (what I have not yet found mentioned by any writer) that, even in the midſt of the water, we may ſuppoſe a pillar of water, of a baſis equal to the ſide of an immerſed body, (and reaching to the loweſt part of it;) and that, though this imaginary aqueous pillar, ſuch as in our figure G H, be not included in any ſolid body, or ſtable ſuperficies; nevertheleſs its lower parts will have a lateral preſſure tending outwards, againſt the imaginary ſides, from the weight of the water, that is above theſe ſubjacent and lateral parts; and will have that preſſure increaſed proportionably to the height to which the imaginary pillar reaches above them. Which obſervation, being duly noted and applied, may be of no mean uſe in the explication of divers hydroſtatical phænomena.

AND laſtly, if, inſtead of holding E F, the longer leg of our ſiphon, perpendicular, (and conſequently the ſhorter parallel to the horizon,) you variouſly incline the former, ſo as to bring it to make an obtuſe or an acute angle with the ſuperficies of the water A B; though by this means the ſhorter and immerſed leg, F G, will in ſituation ſometimes reſpect the bottom, and ſometimes the top of the glaſs; yet in all theſe oblique ſituations of this leg, and the immerſed orifice of it, G, the oblique preſſure of the water will ſo much depend upon the height of the ſurface of the liquor above the orifice, and ſo much conform to the obſervations already delivered, that you ſhall ſtill ſee the ſurface of the oil I K, in the longer pipe, to be a little, and but a little ſuperiour to that of the external water, A B, and ſo the æquilibrium betwixt the liquor, or liquors, within the ſiphon, and the water without it, will even in this caſe alſo be maintained.

SCHOLIUM.

REMEMBRING on this occaſion an experiment, which, though it do not ſhew what the preciſe quantity of lateral preſſure is, that the lower parts of the fluid may ſuſtain from the more elevated; yet it may confirm the foregoing paradox, and by its phænomena afford ſome hints, that may render it not unacceptable; I ſhall ſubjoin it, as I ſet it down not long after I deviſed it.

IN the firſt place then, there was made a glaſs bubble with a ſlender neck; and (in a word) of the figure expreſſed in the annexed ſcheme: this bubble I cauſed to be ſo poiſed, that, though it would float upon the water, yet the addition of a weight ſmall enough would ſuffice to make it ſink. *Fig.* XIV.

THIS done, I provided a very large wide-mouthed glaſs, and cauſed to be fitted to it, as exactly as I could, a ſtopple of cork, which being ſtrongly thruſt in, would not eaſily be lifted up. In the middle of this cork there was burned, with a heated inſtrument, a round hole; through which was thruſt a long ſlender pipe of glaſs; ſo that the lower end of it was a pretty way beneath the cork, and the upper part of it was, as near as could be, at right angles with the upper part of the ſaid cork. And in another part of the ſtopple, near the edge, there was made another round hole, into which was likewiſe thruſt another ſmall pipe; whoſe lower part reached alſo a pretty way beneath the cork, but its upper part was but about two or three inches high; and the orifice of this upper part was carefully cloſed with a ſtopple and cement. Then the glaſs-veſſel being filled with water, and the poiſed bubble being made to float upon it, the ſtopple or cover of the great glaſs-veſſel was put on, and made faſt with a cloſe cement, that nothing might get in or out of the veſſel, but at the long ſlender pipe; which was faſtned into the cork (as was alſo the ſhorter pipe) not only by its own fitneſs to the hole it paſſed through, but by a ſufficient quantity of the ſame cement, carefully applied to ſtop all crevices.

THE inſtrument thus prepared, (and inclined this or that way, till the floating bubble was at a good diſtance from that end

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of the long pipe, which reached a pretty way downwards beneath the ſurface of the water,) we began to pour in ſome of that liquor at the open orifice of the pipe E F ; and, the mouth of the veſſel being exactly ſtopped, the water, for want of another place to receive it, aſcended into the pipe, through which it had fallen before. And, if I held my hand, when the water I had poured in was able to reach but to a ſmall height in the cylinder, as for inſtance, to the ſuperficies J ; the bubble X would yet continue floating. But, if I continued pouring, till the water in the pipe had attained a conſiderable height above the ſurface of that in the veſſel, as if it reached to K ; then the bubble X would preſently ſink to the bottom of the veſſel, and there continue, as long as the water continued at ſo great a height in the pipe E F.

THIS experiment will not only teach us, that the upper parts of the water gravitate upon thoſe, that are under them, but (which is the thing we are now to confirm) that in a veſſel, that is full, all the lower parts are preſſed by the upper, though theſe lower be not directly beneath the upper, but aſide of them, and perhaps at a good diſtance from the line, in which they directly preſs ; theſe things, I ſay, may be made out by our experiment. For the addition of the cylinder of water K J, in the pipe E F, makes the bubble X ſubſide ; as the force or preſſure of any other heavy body upon the water in the veſſel would do. And ſince (as may be gathered from the reaſon formerly given, in the proof of the ſecond paradox, of the ſinking of poiſed bubbles) the included air in our bubble was notably compreſſed ; it will follow, that the cylinder of water K I did preſs the ſubjacent water in the veſſel: for, without ſo doing, it could not be able to compreſs the air in the bubble. And ſince the ſaid bubble did not ſwim directly under, or near the pipe E F, but at one ſide of it, and at a pretty diſtance from it, nay, and floated above the lower orifice F of the pipe ; it is evident, that that aqueous cylinder J K does not only preſs upon the water, or other bodies, that are directly under it ; but upon thoſe alſo, that are laterally ſituated in reſpect of it, provided they be inferiour to it.

AND, according to this doctrine, we may conceive, that every aſſignable part of the ſides of the veſſel does ſuſtain a preſſure, increaſed by the increaſe of that part's depth under water, and according to the largeneſs of the ſaid part. And therefore, if any part were ſo weak, as that it would be eaſily beaten out, or broken by a weight equal to the cylinder I K, (making always a due abatemen for the obliquity of the preſſure) it would not be fit to be a part of our veſſel : nay, the cork itſelf, though it be above the ſurface of the water in the veſſel ; yet, becauſe the water in the pipe is higher than it, each of its parts reſiſts a conſiderable preſſure, proportionate to its particular bigneſs, and to the height of the water in the pipe. And therefore, if the cork be not well ſtopped in, it may be lifted up by the preſſure of the water in the pipe, if that be filled to a good height. And if the cement be not good and cloſe, the water will (not without noiſe) make itſelf a paſſage through it. And if the ſtopple G, of the ſhorter pipe G H, (which is placed there likewiſe to illuſtrate the preſent conjecture) do not firmly cloſe the orifice of it, it may be forced out, not without violence and noiſe. And, for further ſatisfaction, if, inſtead of the ſtopple G, you cloſe the orifice with your finger, you ſhall find it preſſed upwards as ſtrongly, as it would be preſſed downwards by the weight of a cylinder of water of the breadth of the pipe, and of a not inconſiderable height, (for it is not eaſy to determine preciſely, what height :) ſo that (to be ſhort) in the fluid body we made our trial with, the preſſure of the ſuperiour parts was communicated, not only to thoſe, that were placed directly under them, but even to thoſe, that were but obliquely ſo, and at a diſtance from them.

I HAD forgot to confirm, that it was the preſſure of the ſuperiour parts of the water, that made our floating bubble ſink, by ſuch another circumſtance, as I took notice of in ſome of the former experiments ; *viz.* that, when it lay quietly at the bottom of the veſſel, if, by inclining the inſtrument, we poured off as much of the water in the pipe E F, as ſufficed competently to diminiſh its height above the water in the veſſel A B C D, the air in the bubble, finding its former preſſure alleviated, would preſently expand itſelf, and make the bubble emerge. And to ſhow, that the very oblique preſſure, which the bubble ſuſtained from the water in the pipe, was not overmuch differing from that, which it would have ſuſtained from an external force, or from the weight of water placed directly over it ; I cauſed two ſuch bubbles to be poiſed, and having put each of them into a long cylindrical glaſs, open above, and filled with water, upon which it floated, if we thruſt it down a little way, it would (agreeably to what hath been above related) aſcend again : ſo that we we were forced to thruſt it down to a good depth, before the preſſure of the incumbent water was great enough to make it ſubſide. *See the proof of the ſecond paradox.*

AND, perhaps, it will not be impertinent to take notice, before we conclude, how the preſſure of ſuch differing fluids, as air and water, may be communicated to one another. For having ſometimes forborn to fill the veſſel A B C D quite full of water, ſo that, when the cork was fitted to it, there remained in it a pretty quantity of air, (as between the ſurface L M, and the cork ;) nevertheleſs, if the ſtopple or cork were very cloſely put in, the preſſure of the water, that was afterwards poured into the pipe E F, from J to K, would make the bubble ſink little otherwiſe, for aught I took notice of, than if the veſſel had been perfectly filled with water ; the air, (above L M,) that was both impriſoned and compreſſed, communicating the preſſure it received to the water contiguous to it.

PARADOX

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PARADOX VIII.

That water may be made as well to depreſs a body lighter than itſelf, as to buoy it up.

HOW ſtrange ſoever this may ſeem to thoſe, that are prepoſſeſſed with the vulgar notions about gravity and levity; it need not be marvelled at by thoſe, that have conſidered, what has been already delivered. For ſince, in fluid bodies, the upper parts preſs upon the lower, and upon other bodies, that lie beneath them: and ſince, when a body is unequally preſſed by others, whether lighter, or heavier than itſelf, it muſt neceſſarily be thruſt out of that place, where it is more preſſed, to that, where it is leſs preſſed; if that a parcel of oil be, by a contrivance, ſo expoſed to the water, as that the water preſſes againſt its upper ſuperficies, and not againſt the undermoſt, or lateral parts of it; if we ſuppoſe, that there is nothing (whoſe preſſure is not inferiour to that of the water) to hinder its deſcent, (ſuppoſing, withal, that the oil and water cannot paſs by one another; for which cauſe we make uſe of a ſlender pipe;) the oil muſt neceſſarily give way downwards, and conſequently be depreſſed, and not buoyed up. This is eaſily exemplified by the following experiment:

TAKE a ſlender glaſs ſiphon EFGH, of *Fig.* XV. the bore we have often mentioned, whoſe ſhorter leg GH may be about three or four inches long, and as parallel, as the artificer can make it, to the longer EF; dip the ſhorter leg in oil of turpentine, till the oil quite fill the ſhorter leg, and reach to an equal height in the longer, as from F to J. Then, ſtopping the orifice E of the longer leg with your finger, and immerſing the repleniſhed part of the ſiphon about an inch under water, you ſhall perceive, that, as you thruſt it lower and lower, upon the removal of your finger, the oil in the ſhorter leg will be made to ſink about an inch, or ſomewhat more; and as, afterwards, you thruſt the pipe deeper, the oil in the ſhorter leg will, by the weight of the incumbent water HK, be driven downward more and more, till it come to the very bottom of the ſhorter leg; whence, by continuing the immerſion, you may impel it into the longer. The cauſe of which phænomenon I ſuppoſe to be already clearly enough aſſigned, to make it needleſs to add any thing here about it.

IT remains, that, before I proceed to *Fig.* XVI. the next propoſition, I add; that, to exemplify at once three paradoxes, (both this, and the next foregoing, and the ſecond,) I cauſed to be made a ſlender glaſs-pipe, of the figure expreſſed in the annexed ſcheme, and having, by the lower orifice L, ſucked into it as much oil of turpentine, as reached, in the longeſt leg NO, as high as the top of the other part of the glaſs; (namely, to the part P, in the ſame level with the orifice L;) I firſt ſtopped the upper orifice of it, O, with my finger. And then, thruſting it as before under water to a convenient depth, upon the removal of my finger, the external water did firſt drive away the oil, that was in LM, that part of the crooked pipe which was parallel to the horizon; then it depreſſed the ſame oil to the bottom of the ſhorter leg, that is, from M to N: and laſtly, it impelled it all up into the longer leg NPO, to what height I thought fit. So that the oil was preſſed, by the water, both laterally, downwards, and upwards: the cauſes of which are eaſily deducible from the doctrine already delivered.

PARADOX IX.

That, whatever is ſaid of poſitive levity, a parcel of oil lighter than water, may be kept in water without aſcending in it.

TO make out what I have to repreſent about this paradox the more intelligible, the beſt way perhaps will be to ſet down the conſiderations, that induced me to judge the thing it pretends to feaſible. And in order to this, it would be expedient to conſider, why it is, that a body lighter *in ſpecie* than water, being placed never ſo much beneath the ſuperficies of that liquor, will rather emerge to the top, than ſink to the bottom of it; if we had not already conſidered that problem in the explication of the third paradox. But being now allowed to apply to our preſent purpoſe what hath been there delivered, I ſhall forthwith ſubjoin, that it was eaſy enough for me to collect from hence, that the reaſon, why it ſeems not poſſible, that a parcel of oil lighter than water ſhould without violence be kept from emerging to the top of it, being this, *That ſince the ſurface of a veſſel full of ſtanding water is (phyſically ſpeaking) horizontal, the water, that preſſes againſt the lower part of the immerſed body, muſt needs be deeper than that, which preſſes againſt the upper:* If I could ſo order the matter, that the water, that leans upon the upper part of the body ſhould, by being higher than the level of the reſt of the water, have a height great enough to balance that, which preſſes againſt the lower, (and the bodies not ſhift places, by paſſing one by the other) the oil might be kept ſuſpended betwixt two parcels of water.

To reduce this to practice, I took the following courſe; having ſucked into a ſlender pipe (ſuch as that imployed about the firſt experiment) about an inch of water, and kept it ſuſpended there, by ſtopping the orifice of the pipe; I thruſt the lower part of the pipe about two inches beneath the ſurface of ſome oil of turpentine (which, to make the effect the clearer, I ſometimes tinge deeply with copper:) then removing my finger, the oil being preſſed againſt the immerſed orifice with a greater force, than the weight of ſo little ſuſpended water could reſiſt, that oil was impelled into the lower part of the pipe to the height of near an inch; and then again I ſtopped the upper orifice of the pipe with my finger, and thereby keeping both the liquors ſuſpended in it, I thruſt the pipe into a glaſs full of water, three or four inches beneath the ſurface of it; and then (for the reaſon

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reaſon juſt now given) the water, upon the removal of my finger, will preſs in at the lower orifice of the pipe, and impel up the oil, till they come to ſuch a ſtation, as that expreſſed *Fig.* XVII. in the annexed ſcheme: where P Q is the water, newly impelled up into the pipe, Q R is the oil, and R S the water, that was at firſt ſucked into the pipe. For in this ſtation theſe three liquors do altogether as much gravitate upon the part P, as the incumbent water alone does upon the other parts of the imaginary ſuperficies G H; and yet the oil, R Q, does not aſcend, becauſe the diffluence of the water, R S, being hindered by the ſides of the pipe, its ſuperficies, T S, is higher than A D, the ſuperficies of the reſt of the water; by which means the incumbent water may be brought to have upon the upper part R of the oleous cylinder, as great a preſſure as that of the water, that endeavours to impel upwards the lower part Q of the ſame ſuſpended cylinder of oil.

PARADOX X.

That the cauſe of the aſcenſion of water in ſiphons, and of its flowing through them, may be explicated without having a recourſe to nature's abhorrency of a vacuum.

BOTH philoſophers and mathematicians having too generally confeſt themſelves reduced to fly to a *fuga vacui*, for an account of the cauſe of the running of water, and other liquors through ſiphons: and even thoſe moderns, that admit a vacuum, having (as far as I have met with) either left the phænomenon unexplicated, or endeavoured to explain it by diſputable notions: I think the curious much obliged to Monſieur *Paſcal*, for having ingeniouſly endeavoured to ſhew, that this difficult problem need not reduce us to have recourſe to a *fuga vacui*. And indeed his explication of the motion of water in ſiphons, ſeems to me ſo conſonant to hydroſtatical principles, that I think it not neceſſary to alter any thing in it. But as for the experiment he propounds to juſtify his ratiocination, I fear his readers will ſcarce be much invited to attempt it. For, beſides that it requires a great quantity of quickſilver, and a new kind of ſiphon, fifteen or twenty foot long; the veſſels of quickſilver muſt be placed ſix or ſeven yards under water, that is, at ſo great a depth, that I doubt whether men, that are not divers, will be able conveniently to obſerve the progreſs of the trial.

WHEREFORE we will ſubſtitute a way, which may be tried in a glaſs tube, not two foot deep, by the help of another peculiarly contrived glaſs, to be prepared by a ſkilful hand. Provide then a glaſs tube A B C D, of a good wideneſs, and half a yard or more in depth; provide alſo a ſiphon of two legs, F K, and K G, whereunto is joined (at the upper part of the ſiphon) a pipe E K, in *Fig.* XVIII. ſuch manner, as that the cavity of the pipe communicates with the cavities of the ſiphon: ſo that if you ſhould pour in water at E, it would run out at F and G. To each of the two legs of this new ſiphon muſt be tied with a ſtring a pipe of glaſs, I and H, ſealed at one end, and open at the other; at which it admits a good part of the leg of the ſiphon to which it is faſtned, and which leg muſt reach a pretty way beneath the ſurface of the water, wherewith the ſaid pipe is to be almoſt filled. But as one of theſe legs is longer than the other, ſo the ſurface of the water in the ſuſpended pipe I, that is faſtned to the ſhorter leg K F, muſt be higher (that is, nearer to K or A B) than the ſurface of the water in the pipe H, ſuſpended from the longer leg K G; that (according to what is uiual in ſiphons) the water may run from a higher veſſel to a lower.

ALL things being thus provided; and the pipe E K being held, or otherwiſe made faſt, that it may not be moved; you muſt gently pour oil of turpentine into the tube A B C D, (which, if you have not much oil, you may beforehand fill with water, till the liquor reach near the bottom of the ſuſpended pipes, as to the ſuperficies X Y) till it reach higher than the top of the ſiphon F K G, (whoſe orifice E you may, if you pleaſe, in the mean time cloſe with your finger, or otherwiſe, and afterwards unſtop) and then the oil preſſing upon the water, will make it aſcend into the legs of the ſiphon; and paſs through it, out of the uppermoſt veſſel J, into the lowermoſt H; and if the veſſel J were ſupplied with water, the courſe of the water through the ſiphon would continue longer, than here (by reaſon of the paucity of water) it can do.

Now in this experiment we manifeſtly ſee the water made to take its courſe through the legs of a ſiphon from a higher veſſel into a lower; and yet the top of the ſiphon being perforated at K, the air has free acceſs to each of the legs of it, through the hollow pipe E K, which communicates with them both. So that, in our caſe, (where there is no danger of a vacuum, though the water ſhould not run through the ſiphon) the fear of a vacuum cannot with any ſhew of reaſon be pretended to be the cauſe of its running. Wherefore we muſt ſeek out ſome other.

AND it will not be very difficult to find, that it is partly the preſſure of the oil, and partly the contrivance and ſituation of the veſſels; if we will but conſider the matter ſomewhat more attentively. For the oil, that reaches much higher than K, and conſequently than the legs of the ſiphon, preſſes upon the ſurface of the external water, in each of the ſuſpended pipes I and H. I ſay the external water, becauſe the oil floating upon the water, and the orifices of both the legs F and G, being immerſed under the water, the oil has no acceſs to the cavity of either of thoſe legs. Wherefore, ſince the oil gravitates upon the water without the legs, and not upon that within them, and ſince its height above the water is great enough to preſs up the water into the cavity

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of the legs of the ſiphon, and impel it as high as K, the water muſt by that preſſure be made to aſcend.

AND this raiſing of the water happening at firſt in both legs, (for the cauſe is in both the ſame) there will be a kind of conflict about K betwixt the two aſcending portions of water; and therefore we will now examine, which muſt prevail.

AND if we conſider, that the preſſure, ſuſtained by the two parcels of water in the ſuſpended pipes I and H, depends upon the height of the oil, that preſſes upon them reſpectively; it may ſeem (at the firſt view) that the water ſhould be driven out of the lower veſſel into the higher. For if we ſuppoſe that part of the ſhorter leg, that is unimmerſed under water, to be ſix inches long, and the unimmerſed part of the longer leg to be ſeven inches; becauſe the ſurface of the water in the veſſel I is an inch higher than that of the water in the veſſel H, it will follow, that there is a greater preſſure upon the water, whereinto the longer leg is dipped, by the weight of an inch of oil: ſo that that liquor being an inch higher upon the ſurface of the water in the pipe H, than upon that in the pipe I, it ſeems, that the water ought rather to be impelled from H towards K, than from I towards K.

BUT then we muſt conſider, that, though the deſcent of the water in the leg G be more reſiſted than that in the other leg, by as much preſſure as the weight of an inch of oil can amount to; yet being longer by an inch than the water in the leg F, it tends downwards more ſtrongly by the weight of an inch of water, by which length it exceeds the water in the oppoſite leg. So that an inch of water being (*cæteris paribus*) heavier than an inch of oil; the water in the longer leg, notwithſtanding the greater reſiſtance of the external oil, has a ſtronger endeavour downwards, than has the water in the ſhorter leg; though the deſcent of this be reſiſted but by a depth of oil leſs by an inch. So that all things computed, the motion muſt be made towards that way, where the endeavour is moſt forcible; and conſequently the courſe of the water muſt be from the upper veſſel, and the ſhorter leg into the longer leg, and ſo into the lower veſſel.

THE application of this to what happens in ſiphons is obvious enough. For, when once the water is brought to run through a ſiphon, the air (which is a fluid, and has ſome gravity, and has no acceſs into the cavity of the ſiphon) muſt neceſſarily gravitate upon the water, whereinto the legs of the ſiphon are dipped, and not upon that, which is within the ſiphon: and conſequently, though the incumbent air have ſomewhat a greater height upon the water in the lower veſſel, than upon that in the upper; yet the gravitation it thereby exerciſes upon the former more than upon the latter, being very inconſiderable, the water in the longer leg much preponderating (by reaſon of its length) the water in the ſhorter leg, the efflux muſt be out of that leg, and not out of the other. And the preſſure of the external air being able to raiſe water (as we find by ſucking pumps) to a far greater height, than that of the ſhorter leg of the ſiphon; the efflux will continue, for the ſame reaſon, till the exhauſtion of the water, or ſome other circumſtance, alter the caſe. But, if the legs of the ſiphon ſhould exceed thirty four or thirty five foot of perpendicular altitude, the water would not flow through it; the preſſure of the external air being unable (as has been elſewhere declared) to raiſe water to ſuch a height. And if a hole being made at the top of a ſiphon, that hole ſhould be unſtopped, while the water is running, the courſe of it would preſently ceaſe. For, in that caſe, the air would gravitate upon the water, as well within as without the cavity of the ſiphon; and ſo the water in each leg would, by its own weight, fall back into the veſſel belonging to it. *In the Phyſico-mechanical Experiments.*

BUT becauſe this laſt circumſtance, though clearly deducible from hydroſtatical principles and experiments, has not, that I know of, been verified by particular trials, I cauſed two ſiphons to be made, the one of tin, the other of glaſs; each of which had, at the upper part of the flexure, a ſmall round hole or ſocket, which I could ſtop and unſtop, at pleaſure, with the pulp of my finger. So that, when the water was running through the ſiphon, in caſe I removed my finger, the water would preſently fall, partly into one of the ſubjacent veſſels, and partly into the other. And if the legs of the ſiphon were ſo unequal in length, that the water in the one had a far greater height (or depth) than in the other; there ſeemed to be, when the liquor began to take its courſe through the ſiphon, ſome light preſſure from the external air upon the finger, wherewith I ſtopped the orifice of the ſocket made at the flexure.

AND on this occaſion I will add, what I have more than once tried; to ſhew, at how very minute a paſſage the preſſure of the external air may be communicated to bodies fitted to receive it. For, having for this purpoſe ſtopped the orifice of one of the above mentioned ſiphons, (inſtead of doing it with my finger) with a piece of oiled paper, carefully faſtned with cement to the ſides of the ſocket; I found, as I expected, that though hereby the ſiphon was ſo well cloſed, that the water ran freely through, yet, if I made a hole with the point of a needle, the air would at ſo very little an orifice inſinuate itſelf into the cavity of the ſiphon, and, thereby gravitating as well within as without, make the water in the legs to fall down into the veſſels. And though, if I held the point of the needle in the hole I made, and then cauſed one to ſuck at the longer leg; this ſmall ſtopple, without any other help from my hand, ſufficed to make the ſiphon fit for uſe: yet if I removed the needle, the air would (not without ſome noiſe) preſently get in at the hole, and put a final ſtop to the courſe of the water. Nor was I able to take out the needle, and put

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put it in again ſo nimbly, but that the air found time to get into the ſiphon; and, till the hole were again ſtopped, render it uſeleſs, notwithſtanding that the water was by ſuction endeavoured to be ſet a running.

PARADOX XI.

That a ſolid body, as ponderous as any yet known, though near the top of the water, it will ſink by its own weight; yet if it be placed at a greater depth than that of twenty times its own thickneſs, it will not ſink, if its deſcent be not aſſiſted by the weight of the incumbent water.

THIS paradox having never been (that I know of) propoſed as yet by any, has ſeemed ſo little credible to thoſe to whom I have mentioned it, (without excepting mathematicians themſelves,) that I can ſcarce hope it ſhould be readily and generally received in this illuſtrious company, upon leſs clear teſtimony, than that of experience. And therefore, though, (if I miſtake not) ſome part of this propoſition may be plauſibly deduced by the help of an inſtrument ingeniouſly thought upon by Monſieur *Paſcal*; yet I ſhall have recourſe to my own method for the making of it out, for theſe two reaſons: the one, that a great part of the paradox muſt be explicated, as well as proved, by the doctrine already ſettled in this paper: the other, that the experiment propoſed by Monſieur *Paſcal*, being to be done in a deep river, and requiring a tube twenty foot long, whoſe bottom muſt be fitted with a braſs cylinder, made with an exactneſs, ſcarce (if at all) to be hoped for from our workmen; if I ſhould build any thing on this ſo difficult an experiment, (which himſelf does not affirm to have ever been actually tried,) I fear moſt men would rather reject the experiment as a chimerical thing, than receive for its ſake a doctrine that appears to them very extravagant.

LET us then, to employ in this caſe alſo the method we have hitherto made uſe of, fill a glaſs veſſel, A B C D, almoſt full of water; only, in regard that there is a great depth of water requiſite to ſome circumſtances of the experiment, this laſt muſt not be ſo ſhallow, as thoſe hitherto employed: but a deep cylinder or tube, ſealed at one end, whoſe depth muſt be at leaſt two or three foot, though its breadth need not be above two or three inches; and, to keep it upright, it may be placed in a ſocket of metal, or wood, of a ſize and weight convenient for ſuch a purpoſe. This glaſs being thus fitted in water, let us ſuppoſe E F to be a round and flat piece of ſolid braſs, having about an inch in diameter, and a fourth, or ſixth part of an inch in thickneſs. This cylinder, being immerſed under water, till it be juſt covered by the uppermoſt ſurface of that liquor, and being let go, muſt neceſſarily fall downwards in it; becauſe, if we ſuppoſe the imaginary ſuperficies G H to paſs along the circle F, which is the lower part of the braſs body, that metal being *in ſpecie* far heavier than water, the braſs, that leans upon the part F, muſt far more gravitate upon the ſaid part F, than the incumbent water does upon any other part of the ſuperficies G H; and, conſequently, the ſubjacent water at F will be thruſt out of place by the deſcending body. And becauſe that, in what part ſoever of the water, not exceeding nine times its thickneſs, meaſured from the top of the water A C, the ponderous body E F ſhall happen to be; there will be ſtill, by reaſon of the ſpecifick gravity of the metal, a greater preſſure upon that part of the imaginary ſuperficies, that paſſes along the bottom of the body, on which the part F ſhall happen to lean, than upon any other part of the ſame imaginary ſuperficies; the braſs body would ſtill deſcend by virtue of its own weight, though it were not aſſiſted by the weight of the water, that is over it. But let us ſuppoſe it to be placed under water on the deſignable plane J K; and let this plane, which (as all other imaginary planes) is, as well as the real ſurface of the water, to be conceived parallel to the horizon; and let the depth, or diſtance of this plane, from the uppermoſt ſurface of the water, be (ſomewhat) above nine times the thickneſs of the braſs body: I ſay, that, in this caſe, the body would not deſcend, if it were not preſſed downwards by the weight of the water it has over it. For, braſs being but about nine times * as heavy as water of an equal bulk to it, the body E F alone would preſs upon the part F, but as much as a cylinder of water would, which, having an equal baſis, were eight or nine times as high, as the braſs is thick. But now, all the other parts of the imaginary ſurfaces I K being preſſed upon by the incumbent water, which is as high above them, as the newly mentioned cylinder of water would be; there is no reaſon, why the part F ſhould be depreſſed, rather than any other part of the ſuperficies J K: but becauſe it is true, which we formerly taught, namely, that water retains its gravity in water; and that too, though a body, heavier *in ſpecie* than it, be placed immediately under it; it will neceſſarily happen, that in what part ſoever the ſolid body be placed, provided it be every way environed with the water, it muſt, for the reaſon newly given, be made to move downwards, partly by its own weight, and partly by that of the incumbent water; and muſt continue to ſink, till it come to the bottom, or ſome other body, that hinders its farther deſcent.

Fig. XIX.

BUT in caſe the water above the ſolid body did not gravitate upon it, and thereby aſſiſt its deſcent; or in caſe, that the incumbent water were, by ſome artifice or other, ſo removed, that none of the lateral water (if I may ſo call it) could ſucceed in its place to lean upon the ſolid; then it will follow, from what

* The word, *about*, is added, becauſe indeed the author, as he elſewhere delivers, did, by exact ſcales, find braſs to weigh between eight and nine times as much as water; but judged it needleſs to his preſent argument, and inconvenient, to take notice of the fraction.

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what we have newly ſhown, that the ſolid would be kept ſuſpended. And in caſe it were placed much deeper in the water, as over-againſt the point L, or M; then, if we conceive the incumbent water to be removed, or fenced off from it, the preſſure of the ſolid alone upon the part F, of the imaginary ſuperficies L M, being very much inferiour to that of the water upon the other parts of the ſame ſurface, the part F would be ſtrongly impelled upwards, by a force proportionate to the difference of thoſe two preſſures. And therefore, ſince I have found by trials, purpoſely made in ſcales marvellouſly exact, and with refined gold, (purer than, perhaps, any that was ever weighed in water) that gold, though much the ponderouſeſt of bodies yet known in the world, is not full twenty times as heavy, as water of the ſame bulk; I kept within compaſs, (as well as employed a round number, as they call it) when I ſaid, that no body (yet known) how ponderous ſoever, will ſubſide in water by its own weight alone, if it were ſo placed under water, that the depth of the water did above twenty times exceed the height of the body; (not to mention here, that, though gold and water being weighed in the air, their proportion is above nineteen to one, yet, in the water, gold does, as other ſinking bodies, loſe as much of its weight, as that of an equal bulk of water amounts to.)

I WAS ſaying juſt now, that, in caſe the brazen body were placed low enough beneath the ſurface of the water, and kept from being depreſſed by any incumbent water, it would be ſupported by the ſubjacent water. And this is that very thing, that I am now to ſhew by an experiment.

LET then the braſs body E F be the cover of a braſs valve, (as in the annexed fi-
Fig. XX. gure:) and let the valve be faſtened with ſome ſtrong and cloſe cement to a glaſs pipe, O P, (open at both ends) and of a competent length and wideneſs. For then the body E F, being the undermoſt part of the inſtrument, and not ſticking to any other part of it, will fall by its own weight, if it be not ſupported. Now then, tying a thread to a button Q, (that is wont to be made in the middle of the doors of braſs valves) you muſt, by pulling that ſtring ſtreight and upwards, make the body E F ſhut the orifice of the valve as cloſe as you can; (which is eaſily and preſently done.) Then, thruſting the valve under water, to the depth of a foot, or more, the cement and the ſides of the glaſs O P, (which reaches far above the top of the water X Y) will keep the water from coming to bear upon the upper part of the body E F; and conſequently, the imaginary ſurface V W, (that paſſes by the lower part of the ſaid body) will, where it is contiguous thereunto, be preſſed upon only by the proper weight of the body E F; but, in its other parts, by the much greater weight of the incumbent water. So that, though you let go the ſtring, (that held the body E F cloſe to the reſt of the inſtrument) the ſaid body will not at all ſink, though there be nothing but water beneath it to ſupport it.

AND to manifeſt, that it is only the preſſure of the water, of a competent depth, that keeps the ſolid ſuſpended; if you ſlowly lift up the inſtrument towards (X Y) the top of the water; you ſhall find, that, though for a while the parts of the valve will continue united, as they were before; yet, when once it is raiſed ſo near the ſurface, (as between the plane J K and X Y) that the ſingle weight of E F, upon the ſubjacent part of the imaginary plane, that paſſes by it, is greater than the preſſure of the incumbent water upon other parts of the ſame plane; that body, being no more ſupported as formerly, will fall down, and the water will get into the pipe, and aſcend therein to the level of the external water.

BUT if, when the valve is firſt thruſt under water, and before you let go the thread, that keeps its parts together, you thruſt it down to a good depth, as to the ſuperficies R S; then, though you ſhould hang a conſiderable weight, as L, to the valve E F, (as I am going to ſhew you a trial with a maſſy cylinder of ſtone broader than the valve, and of divers inches in length) the ſurpluſage of preſſure on the other parts of the plane V W, (now in R S) over and above what the weight of the body E F, and that of the cylindrical ſtone L to boot, can amount to, on that part of the ſurface, which is contiguous to the ſaid body E F, will be great enough to preſs ſo hard againſt the lower part of the valve, that its own weight, though aſſiſted with that of the ſtone, will not be able to disjoin them.

BY which (to note that by the way) you may ſee, that though, when two flat and poliſhed marbles are joined together, we find it is impoſſible to ſever them without force; we need not have recourſe to a *fuga vacui* to explicate the cauſe of their coheſion, whilſt they are environed by the air, which is a fluid not devoid of gravity, and reaching above the marbles, no body knows how high.

AND, to evince, that it is only ſuch a preſſure of the water, as I have been declaring, that cauſes the coheſion of the parts of the valve; if you gently lift it up towards the top of the water, you will quickly find the braſs body E F drawn down by the ſtone (L) that hangs at it; as you will perceive by the water's getting in between the parts of the valve, and aſcending into the pipe.

TO which I ſhall only add, what you will quickly ſee, that, in perfect conformity to our doctrine, the preſſure of the body E F, upon the ſubjacent water, being very much increaſed by the weight of the ſtone, that hangs at it, the valve needs not, as before, be lifted up above the plane J K, to overcome the reſiſtance of the water, being now enabled to do it, before it is raiſed near ſo high.

APPEN-

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APPENDIX I.

Containing an anſwer to ſeven objections, propoſed by a late learned writer, to evince, that the upper parts of water preſs not upon the lower.

AFTER I had, this morning, made an end of reviewing the foregoing papers, there came into my hands ſome queſtions lately publiſhed, among other things, by a very recent writer of Hydroſtaticks. In one of which queſtions, the learned author ſtrongly defends the contrary to what has there been in ſome places proved, and divers places ſuppoſed.

THE author of theſe Erotemata aſſerts, that, *in conſiſtent water, the upper parts do not gravitate, or preſs upon the lower.*

AND therefore, I think it will be neither uſeleſs, nor improper, briefly to examine here the arguments he produces. Not uſeleſs; becauſe the opinion he aſſerts both is, and has long been, very generally received; and becauſe too it is of ſo great importance, that many of the erroneous tenets and concluſions of thoſe, that (whether profeſſedly, or incidentally) treat of hydroſtatical matters, are built upon it. And not improper; becauſe our learned author ſeems to have done his reader the favour to ſum up into one page all the arguments for his opinions, that are diſperſedly to be found in his own, or other mens books. So that, in anſwering theſe, we may hope to do much towards a ſatisfactory deciſion of ſo important a controverſy. And, after what we have already delivered, our anſwers will be ſo ſeaſonable, that they will not need to be long; the things they are built on having been already made out in the reſpective places, whereto the reader is referred.

OUR author then maintains, that, in conſiſtent water, the ſuperiour do not actually preſs the inferiour parts, by the ſeven following arguments.

Object. 1. SAYS he, *Becauſe elſe the inferiour parts of the water would be more denſe than the ſuperiour, ſince they would be compreſſed and condenſed by the weight of them.*

Anſ. BUT, if the corpuſcles, whereof water conſiſts, be ſuppoſed to be perfectly ſolid and hard, the inferiour corpuſcles may be preſſed upon by the weight of the ſuperiour, without being compreſſed, or condenſed by them; as it would happen, if diamond-duſt were laid together in a tall heap: for, though the upper parts, being heavy and ſolid corpuſcles, cannot be denied to lean, and preſs upon the lower; yet theſe, by reaſon of their adamantine hardneſs, would not be thereby compreſſed. And it is poſſible too, that the corpuſcles of water, though not ſo perfectly hard, but that they may a little yield to an extreme force, be ſolid enough not to admit from ſuch a weight, as that of the incumbent water, (at leaſt in ſuch ſmall heights, as obſervations are wont to be made in,) any compreſſion great enough to be ſenſible; as, beſides ſome trials I have formerly mentioned in another place, thoſe, made in the preſence of this illuſtrious company, ſeem ſufficiently to argue; *viz.* that water is not ſenſibly compreſſible by an ordinary force. And I find not, by thoſe, that make the objection, that they ever took pains to try, whether, in deep places of the ſea, the lower parts are not more condenſed than the upper; nor do I ſee any abſurdity, that would follow from admitting them to be ſo.

Object. 2. OUR author's ſecond argument is; *Becauſe divers feel not, under water, the weight of the water, that lies upon them.*

Anſ. BUT, for anſwer to this argument, I ſhall content myſelf to make a reference to the enſuing appendix, where this matter will be conſidered at large; and where, I hope, it will be made to appear, that the phænomenon may proceed, partly from the firm texture of the diver's body, and partly from the nature of that preſſure, which is exerciſed againſt bodies immerſed in fluids; which, in that caſe, (as to ſenſe) preſſes every where equally againſt all the parts of the body expoſed to their action.

Object. 3. THE third argument is; *That even the ſlighteſt herbs, growing at the bottom of the water, and ſhooting up in it to a good height, are not oppreſſed, or laid by the incumbent water.*

Anſ. BUT the anſwer to that is eaſy, out of the foregoing doctrine. For the plants, we ſpeak of, ſuſtain not the preſſure of the water above them by their own ſtrength, but by the help of the preſſure of water, that is beneath: which, being itſelf preſſed by the water, that is (though not perpendicularly over it) ſuperiour to it, preſſes them upwards ſo forcibly, that, if they were not by their roots, or otherwiſe, faſtened to the ground, they, being *in ſpecie* lighter than water, would be buoyed up to the top of the water, and made to float; as we often ſee that weeds do, which ſtorms, or other accidents have torn from their native ſoil.

Object. 4. A FOURTH objection is this; *That a heavy body, tied to a ſtring, and let down under water, is ſupported, and drawn out with as much eaſe, as it would be, if it had no water incumbent on it; nay, with greater eaſe, becauſe heavy bodies weigh leſs in water, than out of it.*

Anſ. BUT an account of this is eaſy to be rendered out of our doctrine; for, though the water incumbent on the heavy body do really endeavour to make it ſink lower, yet that endeavour is rendered ineffectual to that purpoſe by the equal preſſure of the water upon all the other parts of the imaginary ſurface, that is contiguous to the bottom of the immerſed body. And that preſſure upon the other parts of that ſuppoſed plane being equal, not only to the preſſure of the pillar of water, but to that pillar, and to the weight of as much water, as the immerſed body fills the place of; it muſt needs follow, that not only the hand, that ſuſtains the body, ſhould not feel the weight of the incumbent water, but ſhould be able to lift up the body more eaſily

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in the water, than in the air. But, though the preſſure of the water incumbent on the ſtone cannot, for the reaſon aſſigned, be felt in the caſe propoſed; yet, if you remove that water, (as in the experiment brought for the proof of the laſt paradox,) it will quickly appear by the preſſure againſt the lower part of the heavy body, and its inability to deſcend by its own weight, when it is any thing deep under water; it will, I ſay, quickly appear, by what will follow upon the abſence of the incumbent water, how great a preſſure it exerciſed upon the ſtone, whilſt it leaned on it.

Object. 5. THE fifth argument is propoſed in theſe words; *Becauſe a bucket full of water is lighter in the water, than out of it; nor does weigh more, when full within the water, than when empty out of it; nay, it weighs leſs, for the reaſon newly aſſigned,* (in the fourth objection:) *therefore the water of the bucket, becauſe it is within water, does not gravitate, nor, conſequently, preſs downwards either the bucket, or the water under the bucket.* This is the grand and obvious experiment, upon which the ſchools, and the generality of writers have very confidently built this axiom, *That the elements do not gravitate in their proper place*; and particularly, that water weighs not (as they ſpeak) in its own element.

Anſ. WHAT they mean by *proper*, or natural *place*, I ſhall not ſtand to examine; nor to inquire, whether they can prove, that water, or any other ſublunary body poſſeſſes any place, but upon this account, that the cauſe of gravity, or ſome other movent, enables it to expel other contiguous bodies (that are leſs heavy, or leſs moved) out of the place they poſſeſſed before; and gives it an inceſſant tendency, or endeavour towards the lowermoſt parts of the earth.

BUT, as to the example propoſed, it is very eaſy to give an account of it; for, ſuppoſe A B C D to be a well, wherein, by the ſtring E F, the bucket is ſuſpended under water, and has its bottom contiguous to the imaginary plane I K: if now we ſuppoſe the bucket to conſiſt only of wood lighter than water, it will not only not preſs upon the hand, that holds the rope at E, but will be buoyed up, till the upper parts of the bucket be above the top of the water; becauſe the wood, whereof the bucket is made, being lighter *in ſpecie* than water, the preſſure of the water in the bucket G, and the reſt of the water incumbent on that, together with the weight of the bucket itſelf, muſt neceſſarily be unable to preſs the part H ſo ſtrongly, as the other parts of the imaginary plane I K are preſſed by the weight of the meer water incumbent on them. But if, as it is uſual, the bucket conſiſts partly of wood, partly of iron; the aggregate may often indeed be heavier than an equal bulk of water: but then the hand, that draws up the bucket by the rope F E, ought not, according to our doctrine, to feel the weight of all the bucket, much leſs that of the water contained in it. For though that aggregate of wood and iron, which we here call the bucket, be heavier than ſo much water; yet it tends not downwards with its whole weight, but only with that ſurpluſage of weight, whereby it exceeds as much water, as is equal to it in bulk; which ſurpluſage is not wont to be very conſiderable. And as for the water in the cavity G of the bucket, there is no reaſon, why it ſhould at all load the hand at E, though really the water, both in the bucket and over it, do tend downwards with their full weight; becauſe that the reſt of the water L I, and M K, do full as ſtrongly preſs upon the reſt of the imaginary ſuperficies I K, as the bucket and the incumbent water do upon the part H; and conſequently, the bottom of the bucket is every whit as ſtrongly preſſed upwards by the weight of the water upon all the other parts of the plane I K, as it tends downwards by virtue of the weight of the incumbent water, that is partly in the bucket, and partly above it; and ſo, theſe preſſures balancing one another, the hand, that draws the rope at E, has no more to lift up, than the ſurpluſage of weight, whereby the empty bucket exceeds the weight of as much water, as is equal in bulk (I ſay not to the bucket, as it is a hollow inſtrument, but) to the wood and iron, whereof the bucket conſiſts.

AND becauſe this example of the lightneſs of filled buckets within the water has for ſo many ages gained credit to, if it have not been the only ground of, the aſſertion, that water weighs not in its own element, or in its proper place; I ſhall add (though I can ſcarce preſent it to ſuch a company as this without ſmiles) an experiment, that I made to convince thoſe, that were, through unſkilfulneſs or prejudice, indiſpoſed to admit the hydroſtatical account I have been giving of the phænomenon. I took then a round wooden box, which I ſubſtituted in the room of a bucket; and (having filled it with melted butter, into which, when it was congealed, ſome ſmall bits of lead were put, to make it a little heavier than ſo much water,) I cauſed a ſmall ſtring of twined ſilk to paſs through two ſmall holes, made in the oppoſite parts of the upper edge of the box, and to be ſuſpended at one end of the beam of a pair of goldſmiths ſcales; and then putting it into a veſſel full of water, till it was let down there, to what depth I pleaſed, it appeared, that not only the leaſt endeavour of my hand would either ſupport it, or tranſport to and fro in the water, or draw it up to the top of it; and this, whether the box were made uſe of, or whether the butter and lead alone, without the box, were ſuſpended by the ſilken ſtring: but (to evince, that it was not the ſtrength of my hand, or the ſmallneſs of the immerſed body, that kept me from feeling any conſiderable reſiſtance) I caſt ſome grains into the ſcale, that hung at the other end of the above mentioned beam, and preſently raiſed the lead and butter to the ſurface of the water. So that, unleſs the ſchoolmen will ſay, that the butter and lead were in their own element, we muſt be allowed to think, that the eaſy ſuſtentation, and elevation

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tion of the box, did not proceed from hence, that thoſe bodies weighed not, becauſe they were in their natural place. And yet in this caſe, the effect is the ſame with that, which happens, when a bucket is drawing out of a well.

AND, to manifeſt that it was the preſſure of the water againſt the lower part of the ſurface of our ſuſpended body, that made it ſo eaſy to be ſupported in the water, or raiſed to the top of it; I ſhall add, that though a few grains ſufficed to bring the upper ſurface of the butter to the top of the water, yet afterwards there was a conſiderable weight requiſite to raiſe more and more of its parts above the water's ſurface; and a conſiderabler yet, to lift the whole body quite out of the water. Which is very conſonant to our doctrine. For, ſuppoſe the bucket to be at the part N, half in and half out of the water: the hand or counterpoiſe, that ſupports it in that poſture, muſt have a far greater ſtrength than needed to ſuſtain it, when it was quite under water; becauſe that now the imaginary plain P Q, paſſing by the bottom of the bucket, has on its other parts but a little depth of water, as from L to P, or M to Q; and conſequently the bottom of the bucket, H, will ſcarce be preſſed upwards above half as ſtrongly as when the bucket was quite under water. And if it be raiſed to O, and conſequently quite out of the water; that liquor reaching no longer to the bottom of the buket, can no longer contribute to its ſupportation; and therefore a weight not only equal, but ſomewhat ſuperiour to the full weight of the bucket, and all that it contains (being all ſuppoſed to be weighed in the air) will be neceſſary to lift it clear out of the water.

BUT to dwell longer on this ſubject cannot but be tedious to thoſe, that have been any thing attentive to the former diſcourſes. I proceed therefore to our author's ſixth argument, which is,

Object. 6. *That horſe-hairs, which are held to be of the ſame gravity with water, keep whatever place is given them in that liquor; nor are depreſſed by the weight of the ſuper-incumbent water.*

Anſw. Whether the matter of fact be ſtrictly and univerſally true, is ſcarce worth the examining, eſpecially ſince we find the difference in point of ſpecifick gravity, betwixt moſt horſe-hairs, and moſt waters, to be inconſiderable enough. But the phænomenon, ſuppoſing the truth of it, is very eaſily explicable, according to the doctrine above delivered. For ſuppoſing in the laſt ſcheme the body, R, to be bulk for bulk exactly equiponderant to water; it is plain there is no reaſon, why that body ſhould preſs the part S, of the imaginary ſuperficies I K, either more or leſs than that part S would be preſſed, if the body R being annihilated or removed, it were ſucceeded by a parcel of water of juſt the ſame bulk and weight. And conſequently, though all the water directly above the ſolid R do really lean upon that body, and endeavour to depreſs it; yet that endeavour being reſiſted by an equal and contrary endeavour, that proceeds (as we have been but too often fain to declare) from the preſſure exerciſed upon the other parts of the ſuperficies, I K, by the water incumbent on them; the body R will be neither depreſſed nor raiſed. And its caſe being the ſame in what part of the water ſoever it be placed, provided it be perfectly environed with that liquor; it muſt keep in the water (which in this whole diſcourſe we ſuppoſe to be homogeneous as to gravity) the place you pleaſe to give it.

AND (to add that, on this occaſion) though mathematicians have hitherto contented themſelves to prove, that in caſe a body could be found or provided, that were exactly equiponderant to water, it would retain any aſſignable place in it; yet the curioſity we had, to give an experimental proof of this truth, at length produced ſome glaſs-bubbles, which ſome gentlemen here preſent have not perhaps forgot, that were (by a dextrous hand we imployed about it) ſo exquiſitely poiſed, as, to the wonder of the beholders, to retain the places given them, ſometimes in the middle, ſometimes near the top, and ſometimes near the bottom of the water (though that were homogeneous) for a great while, till ſome change of conſiſtence or gravity in the water, or ſome of its parts, made the bubble riſe or fall.

THE application of this to what has been objected concerning horſe-hairs, being too eaſy to need to be inſiſted on, there remains to be diſpatched our author's ſeventh and laſt argument, which is this:

Object. 7. *That, otherwiſe, all the inferiour parts of the water would be in perpetual motion, and perpetually expelled by the ſuperiour.*

Anſw. But if, by the inferiour parts, he means ſuch portions, as are of any conſiderable bulk; the anſwer newly made to the laſt objection (where we ſhewed, that the body, R, would retain its place any where in the water, and conſequently near the bottom) will ſhew the invalidity of this objection. And unleſs we knew of what bigneſs and ſhape the corpuſcles of water are, it would perhaps be to little purpoſe to diſpute, how far it may be granted, or may be true in the particles, that water is made up of. Only this I ſhall add, that, whereas this learned author mentions it as an abſurdity, that the lower parts of water ſhould be in perpetual motion; and *Stevinus* himſelf, in the beginning of his hydroſtatical elements, ſeems to me to ſpeak ſomewhat inconſiderately of this matter; and though, as I lately ſaid, I allow ſuch ſenſible bodies, as thoſe, whoſe gravity in water writers are wont to diſpute of, to be capable of retaining their places in water, if they be *in ſpecie* equiponderant to it: yet I am ſo far from thinking it abſurd, that the inferiour corpuſcles of water ſhould be perpetually in motion, that I ſee not how otherwiſe they could conſtitute a fluid body, that reſtleſs motion of their parts being one of the generaleſt

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attributes of liquors; and being, in water, though not immediately to be ſeen, yet to be eaſily diſcovered by its effects: as, when ſalt, being caſt into water, the aqueous parts, that are contiguous to it, and conſequently near to the bottom, do ſoon carry up many of the ſaline ones to the very top of the water; where, after a while, they are wont to diſcloſe themſelves in little floating grains of a cubical ſhape.

In the hiſtory of fluidity and firmneſs.

BUT of this reſtleſs motion of the parts of liquors having profeſſedly treated elſewhere already; I ſhall add nothing at preſent, but rather take notice of what our author ſubjoins to the laſt of his arguments, (as the grand thing which they ſuppoſe) in theſe words: *Ratio porro, à priori, hujus ſententiæ videtur eſſe, quia res non dicitur gravitare, niſi quatenus habet infra ſe corpus levius ſe in ſpecie.* The erroneouſneſs of which conceit if I ſhould now go about ſolemnly to evince, I as well fear it would be tedious, as I hope it will be needleſs to thoſe, that have not forgot what may concern this ſubject in the former part of the now at length finiſhed diſcourſe; and eſpecially where I mention thoſe experiments, which ſhow, that neither a ſtone, nor gold itſelf, when placed deep under water, would ſink in it, if the ſuperiour water, that gravitates on it, did not contribute to its depreſſion.

APPENDIX II.

Concerning the reaſon, why divers, and others, who deſcend to the bottom of the ſea, are not oppreſſed by the weight of the incumbent water.

AMONGST the difficulties, that belong to the Hydroſtaticks, there is one, which is ſo noble, and which does ſtill ſo much both exerciſe and poſe the wits of the curious, that perchance it will not be unacceptable, if to the former experiments we add, by way of appendix, one, that may conduce to the ſolving of this difficult problem; *viz.* why men, deep under water, feel no inconvenience by the preſſure of ſo great a weight of water as they are placed under?

THE common anſwer of philoſophers and other writers to this puzzling queſtion is, that the elements do not gravitate in their own proper places; and ſo, water in particular has no gravitation upon water, nor conſequently upon bodies every way ſurrounded with water. But that this ſolution is not to be admitted, may be eaſily gathered from our proofs of the firſt paradox, and from divers other particulars, applicable to the ſame purpoſe, that may be met with in the foregoing papers.

A FAMOUS writer, and, for aught I know, the receneſt (except Monſieur *Paſcal*) that has treated of Hydroſtaticks, having rendered this reaſon of the phænomenon:

[*The ſuperiour parts of conſiſtent water* (as he ſpeaks) *preſs not the inferiour, unleſs beneath the inferiour there be a body lighter* in ſpecie *than water*; *and therefore, ſince a human body is heavier* in ſpecie *than water, it is not preſſed by the incumbent water, becauſe this does not endeavour to be beneath a human body:*] He ſubjoins, contrary to his cuſtom, this confident epiphonema, *Qui aliam cauſam hujus rei aſſignant, errant, & alios decipiunt.*

BUT, by his favour, notwithſtanding this confidence, I ſhall not ſcruple to ſeek another reaſon of the phænomenon. For I have abundantly proved, that (contrary to the aſſertion on which his explication is built) the upper parts of water preſs againſt the lower, whether a body heavier or lighter *in ſpecie* than water be underneath the lower. And, the contrary of which being the πρῶτον ψεῦδος in this controverſy, perhaps the matter may be ſomewhat cleared, by mentioning here a diſtinction, which I ſometimes make uſe of. I conſider then a body may be ſaid to gravitate upon another body in two ſenſes. For ſometimes it actually ſinks into, or gets beneath the body, that was under it, as a ſinking ſtone gravitates upon water, and which I call prevalent, or ſucceſsful gravitation; and ſometimes it does not actually, at leaſt not viſibly deſcend, but only exerciſes its gravitation by preſſing againſt the ſubjacent body that hinders its deſcent: as when a woman carries a pail of water on her head, though the weight do not actually get nearer the center of the earth; yet it actually preſſes with its whole gravity upon the woman's head, and back, and other ſubjacent parts, that hinder its actual deſcent. And, according to this doctrine, I cannot admit our author's reaſoning, that becauſe a man's body is bulk for bulk heavier than water, therefore the water does not endeavour to place itſelf beneath it. For water, being a heavy body, derives from the cauſe of its gravity (whatever that be) an inceſſant endeavour towards the center of the earth; nor is there any reaſon, why its happening to be incumbent on a body heavier *in ſpecie* than itſelf, ſhould deſtroy that endeavour. And therefore, though it may be ſaid, that the water does not endeavour to place itſelf beneath a human body, becauſe indeed an inanimate liquor cannot properly be ſaid to act for this or any other end; yet the water being a heavy body, tends continually towards the lower part of the earth; and therefore will get beneath any body that is placed betwixt it and that, (without regard whether the inferiour body be heavier or lighter *in ſpecie* than itſelf) as far as the degree of its gravity will enable it; nor would it ever reſt, till it have reached the lowermoſt parts of the earth, if the greater ponderouſneſs of the earth, and other heavy bodies, did not hinder, (not its endeavour downwards, nor its preſſure upon ſubjacent bodies, but only) its actual deſcent.

THIS learned author himſelf tells us, (as well as *Stevinus*, and others, that have written of the Hydroſtaticks, unanimouſly teach) that if the bottom of a veſſel be parallel to the horizon, the weight of water, that reſts upon it, is equal to a pillar of water, having that bottom for its baſis, and for its height a perpendicular reaching thence to the uppermoſt

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moſt ſurface of the water. Nor is it reaſonable to conceive, that there will be any difference in this preſſure of the incumbent water, whether the bottom be of deal, that will ſwim, or of box, that will ſink in water; or, to ſpeak more generally, whether it be of wood, *in ſpecie* lighter than water, or of copper, or ſome orher metal, that is *in ſpecie* heavier than it. And ſince water, being not a ſolid body, but a fluid, conſiſts (as other fluids) of innumerable corpuſcles, that, though extremely minute, have their own ſizes and figures; and ſince the preſſure of water upon the bottom of a veſſel is proportionate to its perpendicular height over the bottom; it is manifeſt, that the upper corpuſcles preſs the bottom as well as the lower; which ſince they cannot do immediately, they muſt do by preſſing the intermediate ones. And I have already ſhown (diſcourſing one of the former paradoxes) that the ſuperiour parts of water do not only preſs thoſe, that are directly under them, but communicate a preſſure to thoſe, that are aſide of them, and at a diſtance from them.

AND if it be objected, that water endeavours to get beneath a bottom of glaſs-veſſels, or other bodies heavier *in ſpecie* than itſelf, becauſe under that bottom there is air, which is a lighter body *in ſpecie* than water: I ſay, that this is precarious; for the indiſputable gravity of the water is alone ſufficient to make it always tend downwards, (though it cannot always move downwards) whatever body be beneath it. And who can aſſure the makers of this objection, that there are not beneath even the bottom of rivers, or of the ſea, (where yet they ſay water is conſiſtent, and reſts as in its own place) vaſt ſpaces repleniſhed but with air, fumes, or fire, or ſome other body lighter than water? For, (not to mention, that the Carteſians take the earth we tread on, to be but a thin cruſt of the terreſtrial globe, whoſe inſide, as far as the center, is repleniſhed with a ſubtile fluid matter, like that whereof the ſun conſiſts;) we know that in ſome places, as particularly at a famous coal-mine in *Scotland*, there are great cavities, that reach a good way under that ground, that ſerves there for a bottom to the ſea: ſo that, for aught theſe objectors know, even according to their own doctrine, the water, even in the ſea, may endeavour to get beneath a body heavier *in ſpecie* than itſelf.

BUT, for my part, I cannot but think, that, to imagine the water knows, whether or no there be air or ſome lighter body than itſelf beneath the body it leans on, and the ſuperiour parts do accordingly exerciſe or ſuſpend their preſſure upon the inferiour; is to forget that it is a heavy liquor, and an inanimate body.

ANOTHER ſolution there is of this hydroſtatical problem we have been diſcourſing of, which I met with in a printed letter of Monſieur *Des Cartes*, in theſe terms:

Second Tome, lettre 32.

Je ne me, &c. *I remember not what reaſon it is, that* Stevinus *gives, why one feels not the weight of water, when one is under it: but the true one is, that there can no more of water gravitate upon the body, that is in it, or under it, than as much water as could deſcend in caſe that body left its place. Thus, for example, if there were a man in the barrel* B, *that* Fig. XXII. *ſhould with his body ſo ſtop the hole* A, *as to hinder the water's getting out, he would feel upon himſelf the weight of the whole cylinder of water* A B C, *of which I ſuppoſe the baſis to be equal to the hole* A: *foraſmuch as if he ſunk down through the hole, all the cylinder of water would deſcend too; but if he be a little higher, as about* B, *ſo that he does no longer hinder the water from running out at the hole* A, *he ought not to feel any weight of the water which is over him, betwixt* B *and* C; *becauſe if he ſhould deſcend toward* A, *that water would not deſcend with him, but contrariwiſe a part of the water, which is beneath him towards* A, *of equal bulk to his body, would aſcend into its place: ſo that, inſtead of feeling the water to preſs him from the top downward, he ought to feel, that it buoys him upward from the bottom; which by experience we ſee.*

THUS far this ſubtile philoſopher; for whoſe ratiocinations though I am wont to have much reſpect, yet I muſt take the liberty to confeſs myſelf unſatisfied with this. For, having already ſufficiently proved, that the upper parts of water preſs the lower, and the bodies placed beneath them, whether ſuch bodies be lighter *in ſpecie* than water, or heavier; we have ſubverted the foundation, upon which Monſieur *Des Cartes*'s ingenious, though unſatisfactory, explication is built. And yet I ſhall add, *ex abundanti*, that ſuppoſing what he ſays, that, in caſe the ſolid B ſhould deſcend towards A, the incumbent water would not deſcend with it, but a part of the ſubjacent water, equal in bulk to the ſolid, would aſcend, and ſucceed in its room; yet that is but accidental, by reaſon of the ſtaunchneſs and fulneſs of the veſſel. And though, indeed, the ſuperiour water cannot actually deſcend upon the depreſſion of the ſolid at B, if at the ſame time, while that body deſcends, an equal bulk of water ſucceeds in its place; yet both the ſolid about C, and the water, that ſucceeds it, do, in their turns, hinder the deſcent of the ſuperiour water; which therefore muſt gravitate upon which ſoever of the two it be, that actually comes to be placed directly under it, if there be nothing before the diſplacing of the ſolid capable to take away the natural gravity, upon whoſe account the water over B and C does inceſſantly tend downwards. And though Monſieur *Des Cartes* does not ſo clearly expreſs himſelf, whether he ſuppoſes the hole at A to be ſtopped with ſome other body, when the ſolid is placed about B; yet, becauſe he is wont to ſpeak conſiſtently, I preſume he means, that, when the ſolid is removed to B, the hole at A is otherwiſe ſufficiently ſtopped; I ſay then, that the reaſon, why the ſolid, which, whilſt at A, ſuſtained a great preſſure from the incumbent water, feels not the weight of it, when placed at B, is not that, which Monſieur

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ſieur *Des Cartes* gives, but this; That the ſolid being environed with water, the ſubjacent water does (as we have often had occaſion to manifeſt) preſs it upwards full as ſtrongly, (and ſomewhat more) as the weight of the incumbent water preſſes it downwards; ſo that a man's body, inſtead of ſinking, would be buoyed up, if, as it is a little heavier, it were a little lighter *in ſpecie* than water. Whereas, when the ſolid was that alone, which covered and ſtopped the hole, there was a manifeſt reaſon, why it ſhould be forcibly thruſt downwards by the weight of the incumbent water B C. For, in that caſe, there was no water underneath it at A, to ſupport the ſolid; and, by its preſſure, to enable it to reſiſt ſo great a weight.

AND this (to hint that upon the by) may, perchance, help us to gueſs at the reaſon of what geographers relate of the lake *Aſphaltites* in *Judæa*, (in caſe the matter of fact be true,) that this *Dead Sea* (as they alſo call it) will not ſuffer any living creature to ſink in it. For the body of a man (and, for aught we know, of other animals) is not much heavier *in ſpecie* than common freſh water. Now, if in this lake (that ſtands, where *Sodom* and *Gomorrah* did, before thoſe impious regions were deſtroyed by fire from heaven,) we ſuppoſe, (which the nature of the ſoil, and the ſacred ſtory makes probable enough,) that the water abounds with ſaline, or ſulphurous corpuſcles; (the former helping the latter to aſſociate with the water, as we ſee in ſoap conſiſting of ſalt and oil, and in chymical mixtures of alcalis and brimſtone diſſoluble in water;) the liquor may have its gravity ſo augmented, as to become heavier *in ſpecie* than the body of an animal. For I have learned of a light ſwimmer, that he could hardly begin to dive in ſalt water, though he eaſily could in freſh. And it is not difficult to make a brine or lixivium (which are but ſolutions of ſalt in water) heavy enough to keep up an egg from ſinking. And not only barely by diſſolving a metalline body in a ſaline *menſtruum*, without otherwiſe thickening the liquor, I have brought ſolid pieces of amber itſelf to ſwim upon it; but I have tried, that certain ſaline ſolutions, which I elſewhere mention, nay, and a diſtilled liquor, (I uſed deflegmed oil of vitriol) without any thing diſſolved in it, would do the ſame thing, by reaſon of the numerous, though minute, corpuſcles of ſalt and ſulphur, that it abounds with.

THERE remains but one ſolution more of our hydroſtatical problem, that I think worth mentioning, and that is given by the learned *Stevinus* in theſe words:

*OMNI preſſu, quo corpus dolore afficitur, pars aliqua corporis luxatur; ſed iſto preſſu nulla corporis pars luxatur; iſto igitur preſſu corpus dolore nullo afficitur. Aſſumptio ſyllogiſmi manifeſta eſt; nam ſi pars aliqua, ut caro, ſanguis, humor, aut quodlibet denique membrum luxaretur, in alium locum concedat neceſſe eſſet: atqui locus ille non eſt extra corpus; cum aqua undiquaque æquali preſſu circumfuſa ſit (quod vero pars ima, per undecimam propoſitionem Hydroſtaticorum, paulo validius prematur ſuperiori, id hoc caſu nullius momenti eſt, quia tantula differentia partem nullam ſua ſede dimovere poteſt) neque item intra ipſum corpus concedit, cum iſtic corpore omnia oppleta ſint, unde ſingulæ partes ſingulis partibus æqualiter reſiſtunt, namque aqua undiquaque eadem ratione corpus totum circumſtat. Quare cum locus is nec intra, nec extra corpus ſit; abſurdum, imo impoſſibile fuerit, partem ullam ſuo loco emovere, ideoque nec corpus hic afficitur dolore.**

THIS ſolution of *Stevinus* I eſteem preferable by far to thoſe, that are wont to be given of this difficult problem: but yet the phænomenon ſeems to me to have ſtill ſomewhat in it of ſtrange. It is true, that if the queſtion were only that, which ſome put, *viz.* Why the body of a diver, when it is near the bottom of the ſea, is not preſſed down by ſo vaſt a weight of water, as is incumbent on it? it might be rationally anſwered, That the weight of ſo much water, as leans upon the body, is not ſuſtained by the force of the body itſelf, but by that of the water, which is under it. For, by the experiments and explications, we have annexed to ſome of the foregoing paradoxes, it appears, that the ſubjacent water, by its preſſure upwards, is able, not only to ſupport the weight of the incumbent water, but ſo far to exceed it, that it would not only ſupport the immerſed body, and the incumbent water, but buoy up the body, if it were never ſo little lighter *in ſpecie* than water. And as for what *Stevinus* inſinuates, that, when the water preſſes the body every way, that preſſure is not felt, though it would be, in caſe it preſſed upon ſome parts, and not upon others; I am of the ſame opinion too: and, to prove it, ſhall not make uſe of the example he propoſes, in the words immediately following thoſe of his I juſt now recited; (for I doubt, that example is rather a ſuppoſition, than a tried thing;) but by an experiment, which may be eaſily made, and has divers times been ſo, in our pneumatical engine. For, though the air be a heavy fluid, and though, whilſt it uniformly preſſes the whole ſuperficies of the body, we feel not the preſſure of it; and though, for this reaſon, you may lay the palm of your hand upon the open orifice of a ſmall braſs cylinder, applied to the engine inſtead of a receiver, without any hurt: yet when, by pumping, the air, that was before under the palm of your hand, is withdrawn, and conſequently can no longer help to ſupport your hand againſt the preſſure of the external and incumbent air, the external air will lean ſo heavy upon the back of your hand, that you

* *Stevinus Hydroſtat. lib. 5. pag.* 149.

Sed exemplo clarius ita intelliges, eſto A B C D *aqua, cujus fundum* D C, *in quo foramen* E *habeat epiſtomium ſibi inſertum, cui dorſo incumbat homo* F. *Quæ cum ita ſint, ab aquæ pondere ipſi inſidente nulla pars corporis luxari poterit, cum aqua, ut dictum eſt, undiquaque æqualiter urgeat.* Fig. XXIII.

Si vero ejus veritatem explorare libeat, eximito epiſtomium, tumque tergum nulla re fultum ſuſtinebitur, ut in locis cæteris, ideoque iſtic tanto preſſu afficietur, quantus tertio exemplo ſecundæ propoſitionis hujus demonſtratus eſt: vid. *quantum efficit columna aquea, cujus baſis ſit foramen* E, *altitudo autem eadem quæ aquæ ipſi inſidentis. Quo exemplo propoſiti veritas manifeſte declaratur.*

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you will imagine, ſome ponderous weight is laid upon it. And I remember, by ſuch an experiment, I have not only had my hand put to much pain, but have had the back of it ſo bent downward, as if it were going to be broken.

BUT though ſuch conſiderations, as theſe, may much leſſen the difficulty of our phænomenon, whoſe cauſe is inquired into; yet ſtill it ſeems ſomewhat odd to me, that (ſince it is evident from the nature of the thing, and by *Stevinus*'s confeſſion, that there is a vaſt preſſure of water againſt every part of the body, whoſe endeavour tends inward,) ſo exceedingly forcible and preſſure, (which thruſts, for inſtance, the muſcles of the arms and thighs againſt the bones, and ſkin and fleſh of the thorax againſt the ribs,) ſhould not put the diver to any ſenſible pain; as I find not (by one that I examined) that it does; (though this man told me, he ſtayed a good while at the depth of betwixt eighty and one hundred foot under the ſea-water, which is heavier than freſh water:) for, that which *Stevinus*'s explication will only ſhow is, that there muſt be no manifeſt diſlocation of the greater parts of the body; whereas the bare compreſſion of two ſmall parts, one againſt another, is ſufficient to produce a ſenſe of pain.

BUT it ſeems, the texture of the bodies of animals is better able to reſiſt the preſſure of an every way ambient fluid, than, if we were not taught by experience, we ſhould imagine. And therefore, to ſatisfy thoſe, that (ſecluding the queſtion about the ſenſe of pain) think it an abundantly ſufficient argument, (to prove, that bodies immerſed under water, are not compreſſed by it,) that divers are not oppreſſed, and even cruſhed by ſo vaſt a load of water, (amounting, by *Stevinus*'s computation, to many thouſands of pounds) as is incumbent on them: we will add, that though an experiment, propoſed by Monſieur *Paſcal* to this purpoſe, were ſuch, that at firſt ſight I ſaid, that it would not ſucceed, (and was not upon trial miſtaken in my conjecture;) yet it gave me the occaſion to make another, which will, I hope, fully make out the thing I deſigned it for.

THE ingenious Monſieur *Paſcal* would perſuade his readers, that if into a glaſs veſſel, with luke-warm water in it, you caſt a fly; and, by a rammer, forcibly preſs that water, you ſhall not be able to kill, or hurt the fly. Which, ſays he, will live as well, and walk up and down as lively, in lukewarm water, as in the air. But, upon trial with a ſtrong fly, the animal was (as we expected) preſently drowned, and ſo made moveleſs, by the lukewarm water.

WHEREFORE we ſubſtituted another experiment, that we knew would not only ſucceed, (as you will preſently ſee it will do,) but teach us how great a preſſure the included animal muſt have been expoſed to. We took then a *Fig.* **XXIV.** ſomewhat ſlender cylindrical pipe of glaſs, ſealed at one end, and open at the other; and to this we fitted a rammer, which (by the help of ſome thongs of ſoft leather, that were carefully wound about it) did ſo exactly fill the pipe, that it could not eaſily be moved to and fro; and would ſuffer neither water, nor air, to get by betwixt it and the internal ſurface of the glaſs. We alſo provided ſome ſmall tadpoles (or *Gyrini*) about an inch long or leſs; which ſort of animals we made choice of before any other, partly becauſe they could, by reaſon of their ſmallneſs, ſwim freely to and fro in ſo little water as our pipe contained; and partly becauſe thoſe creatures, being as yet but in their infancy, were more tender, and conſequently far more expoſed to be injured by compreſſion, than other animals of the ſame bulk, but come to their full age and growth, would be; (as indeed ſuch young tadpoles are ſo ſoft and tender, that they ſeem, in compariſon to the bigger ſort of flies, to be but organized gelly.) One of theſe tadpoles being put into the water, and ſome inches of air being left in the pipe, for the uſe anon to be mentioned; the water and air, and conſequently the tadpole, were by the intruſion of the plug or rammer, with as great a force, as a man was able to employ, violently compreſſed; and yet, though the tadpole ſeemed to be compreſſed into a little leſs bulk than it was of before, it ſwam freely up and down the water, without forbearing ſometimes to aſcend to the very top, though the inſtrument were held perpendicular to the horizon. Nor did it clearly appear to us, that the little animal was injured by this compreſſion; and moſt manifeſt it is, he was not cruſhed to death, or ſenſibly hurt by it.

AND having repeated this experiment ſeveral times, and with tadpoles of differing ages; we may, I preſume, ſafely conclude, that the texture of animals is ſo ſtrong, that, though water be allowed to weigh upon water, yet a diver ought not to be oppreſſed by it: ſince, whether or no water weighs in water, it is manifeſt, that in our experiment, the water, and conſequently the tadpole, was very forcibly by an external agent compreſſed betwixt the violently condenſed air, and the rammer. And, by the notice we took of the quantity of air before the compreſſion began, and that to which it was reduced by compreſſion; the moderateſt eſtimate we could make, was, that it was reduced into an eighth, or tenth part of its former ſpace; and ſo (according to what we have elſewhere proved) the preſſure, that was upon the air, (and conſequently upon the water, and the included tadpole,) was as great, as that of a cylinder of water, of above two hundred, if not three hundred foot high. And yet all this weight being unable to oppreſs, or ſo much as manifeſtly to hurt, the tender tadpole, (which a very ſmall weight would ſuffice to have cruſhed, if it preſſed only upon one part of it, and not upon the other;) we may thence learn the truth of what we have been endeavouring to evince: That though water be allowed to preſs againſt water, and all immerſed bodies; yet a diver may very well remain unoppreſſed at a great depth under water, as long as the preſſure of it is uniform againſt all the parts expoſed thereunto.

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A Confirmation of the former * ACCOUNT touching the late EARTHQUAKE near *Oxford*, and the Concomitants thereof.

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AS to the earthquake, your curioſity about it makes me ſorry, that, though I think I was the firſt, that gave notice of it to ſeveral of the virtuoſi at *Oxford*; yet the account, that I can ſend you about it, is not ſo much of the thing itſelf, as of the changes of the air, that accompanied it. To inform you of which, I muſt relate to you, that riding one evening ſomewhat late, betwixt *Oxford* and a lodging I have at a place four miles diſtant from it, the weather having been for a pretty while froſty, I found the wind ſo very cold, that it reduced me to put on ſome defenſives againſt it; which I never ſince, nor, if I forget not, all the foregoing part of the winter was obliged to make uſe of. My unwillingneſs to ſtay long in ſo troubleſome a cold, which continued very piercing, till I had got half way homeward, did put me upon galloping at no very lazy rate; and yet, before I could get to my lodgings, I found the wind turned, and felt the rain falling: which, conſidering the ſhortneſs of the time, and that this accident was preceded by a ſettled froſt, was ſurpriſing to me, and induced me to mention it at my return, as one of the greateſt and ſuddeneſt alterations of air I had ever obſerved. And what changes I found, have been taken notice of in the gravity of the atmoſphere at the ſame time, by that accurate obſerver * Dr. *Wallis*, who then ſuſpected nothing of what followed, as, I ſuppoſe, he has ere this told you himſelf. Soon after, by my gueſs about an hour, there was a manifeſt trembling in the houſe, where I was, (which ſtands high in compariſon of *Oxford*;) but it was not there ſo great, but that I, who chanced to have my thoughts buſied enough on other matters than the weather, ſhould not have taken notice of it as an earthquake, but have imputed it to ſome other cauſe, if one, that you know, whoſe hand is employed in this paper, and begins to be a diligent obſerver of natural things, had not advertiſed me of it, as being taken notice of by him, and the reſt of the people of the houſe. And ſoon after there happened a briſk ſtorm; whereupon I ſent to make inquiry at a place called *Brill*, which ſtanding upon a much higher ground, I ſuppoſed, might be more obnoxious to the effects of the earthquake, (of which, had I had any ſuſpicion of it, my having formerly been in one near the *Lacus Lemanus* would have made me the more obſervant:) but the perſon I ſent to, being diſabled by ſickneſs to come over to me, (which he promiſed to do, as ſoon as he could) wrote me only a ticket, whoſe ſubſtance was, That the earthquake was there much more conſiderable, than where I lodged; and that, at a gentleman's houſe, whom he names, (the moſt noted perſon, it ſeems, of the neighbourhood) the houſe trembled very much, ſo as to make the ſtones manifeſtly to move to and fro in the parlour, to the great amazement and fright of all the family. The hill, whereon this *Brill* ſtands, I have obſerved to be very well ſtored with mineral ſubſtances of ſeveral kinds, and from thence I have been informed by others, that this earthquake reached a good many miles; but I have neither leiſure, nor inclination, to entertain you with uncertain reports of the extent and other circumſtances; eſpecially ſince a little further time and inquiry may enable me to give you a better warranted account.

* See Num x. of *Phil. Tranſactions*, p. 166—171; at the time of the printing whereof, this relation of Mr. *Boyle* was not yet come to hand.

Some

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Some OBSERVATIONS and DIRECTIONS about the BAROMETER.

First printed in the *Philoſophical Tranſactions*, N° XI. p. 181. For *April* 2. 1666.

AS to the barometrical obſervations, (as for brevity's ſake I uſe to call them) though you † gueſſed aright, that, when I ſaw thoſe of the learned and inquiſitive Dr. *Beale*, I had not mine by me, (for I left them ſome years ſince in the hands of a virtuoſo, nor have I now the leiſure to look after thoſe papers;) yet ſince, by the communication you have made publick, it is probable, that divers ingenious men will be invited to attempt the like obſervations, I ſhall (notwithſtanding my preſent haſte) mention to you ſome particulars, which, perhaps, will not appear unſeaſonable, that came into my mind upon the reading of what you have preſented the curious.

WHEN I did, as you may remember, ſome years ago, publickly expreſs and deſire, that ſome inquiſitive men would make baroſcopical obſervations in ſeveral parts of *England* (if not in foreign countries ‖ alſo;) and, to aſſiſt them to do ſo, preſented ſome of my friends with the neceſſary inſtruments: the declared reaſon of my deſiring this correſpondence was, (among other things) that, by comparing notes, the extent of the *atmoſpherical* changes, in point of *weight*, might be the better eſtimated. But not having hitherto received ſome account, that I hoped for, I ſhall now, without ſtaying for them, intimate thus much to you: That it will be very convenient, that the obſervers take notice, not only of the day, but, as near as they can, of the hour, wherein the height of the mercurial cylinder is obſerved. For I have often found, that within leſs than the compaſs of one day, or, perhaps, half a day, the altitude of it has ſo conſiderably varied, as to make it, in many caſes, difficult to conclude any thing certainly from obſervations, that agree but in the day.

IT will be requiſite alſo, that the obſervers give notice of the ſituation of the place, where their barometers ſtand, not only, becauſe it will aſſiſt men to judge, whether the inſtruments were duly perfected, but principally, becauſe that, though the baroſcope be good, (nay, becauſe it is ſo) the obſervations will much diſagree, even when the atmoſphere is in the ſame ſtate, as to weight, if one of the inſtruments ſtand in a conſiderably higher part of the country, than the other.

TO confirm both the foregoing admonitions, I muſt now inform you, that, having in theſe parts two lodgings, the one at *Oxford*, which, you know, ſtands in a bottom by the *Thames* ſide, and the other at a place four miles thence, ſeated upon a moderate hill; I found, by comparing two baroſcopes, that I made, the one at *Oxford*, the other at *Stanton St. John's*, that, though the former be very good, and have been noted for ſuch, during ſome years, and the latter was very carefully filled; yet by reaſon, that in the higher place, the incumbent part of the atmoſphere muſt be lighter than in the lower, there is almoſt always between two and three eighths of an inch difference betwixt them. And having ſometimes ordered my ſervants to take notice of the diſparity, and divers times carefully obſerved it myſelf, when I paſſed to and fro between *Oxford* and *Stanton*, I generally found, that the *Oxford* barometer, and the other, did, as it were, by common conſent, riſe and fall together ſo, as that in the former the mercury was uſually $\frac{3}{8}$ higher than in the latter.

WHICH obſervations may teach us, that the ſubterraneous ſteams, which aſcend into the air, or the other cauſes of the varying weight of the atmoſphere, do many times, and at leaſt in ſome places uniformly enough affect the air to a greater height than, till I had made this trial, I durſt conclude.

BUT, as moſt of the barometrical obſervations are ſubject to exception, ſo I found the formerly mentioned to be. For (to omit leſſer variations) riding one evening from *Oxford* to *Stanton*, and having, before I took horſe, looked on the baroſcope in the former of theſe two places, I was ſomewhat ſurpriſed to find at my coming to the latter, that in places no farther diſtant, and notwithſtanding the ſhortneſs of the time (which was but an hour and a half, if ſo much) the barometer at *Stanton* was ſhort of its uſual diſtance from the other, near a quarter of an inch, though, the weather being fair and calm, there appeared nothing of manifeſt change in the air, to which I could aſcribe ſo great a variation; and though alſo, ſince that time, the mercury in the two inſtruments hath, for the moſt part, proceeded to riſe and fall as before.

AND theſe being the only obſervations I have yet met with, wherein baroſcopes, at ſome diſtance of place, and difference of height, have been compared (though I cannot now ſend you the reflexions, I have elſewhere made upon them:) as the opportunity I had to make them myſelf, rendred them not unpleaſant to me, ſo perhaps the novelty will keep them from being unwelcome to you.

† See Num. IX. of the *Phil. Tranſact.* p. 159, the laſt paragraph.

‖ Some whereof have been ſince invited by the Publiſher, to give their concurrence herein.

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And I confeſs I have had ſome flying ſuſpicions, that the odd phænomena of the baroſcope, which have hitherto more poſed than inſtructed us, may in time, if a competent number of correſpondents do diligently proſecute the inquiries (eſpecially with baroſcopes, accommodated with Mr. *Hook's* ingenious additions) make men ſome luciferous diſcoveries, that poſſibly we do not yet dream of.

I KNOW not, whether it will be worth while to add, that ſince I was obliged to leave *London*, I have been put upon ſo many leſſer removes, that I have not been able to make baroſcopical obſervations with ſuch a conſtancy as I have wiſhed; but, as far as I remember, the quickſilver has been for the moſt part ſo high, as to invite me to take notice of it; and to deſire you to do me the favour to inquire among your correſpondents whether they have obſerved the ſame thing *. For, if they have, this laſting, (though not uninterrupted) altitude of the quickſilver happening, when the ſeaſons of the year have been extraordinary dry (ſo much as to become a grievance, and to dry up, as one of the late Gazettes informs us, ſome ſprings near *Weymouth*, that uſed to run conſtantly) it may be worth inquiry, whether theſe obſtinate droughts may not, by cleaving of the ground too deep, and making it alſo in ſome places more porous, and, as it were, ſpungy, give a more copious vent, than is uſual to ſubterraneal ſteams; which aſcending into the air, increaſe the gravity of it. The inducements I have to propoſe this inquiry, I muſt not now ſtay to mention. But perhaps, if the obſervation holds, it may prove not uſeleſs in reference to ſome diſeaſes.

PERHAPS it will be needleſs to put you in mind of directing thoſe virtuoſi, that may deſire your inſtructions about baroſcopes, to ſet down in their diaries not only the day of the month, and the hour of the day, when the mercury's height is taken, but (in a diſtinct column) the weather, eſpecially the winds, both as to the quarters, whence they blow (thoughthat be not always ſo eaſy nor neceſſary,) and as to the violence or remiſſneſs wherewith they blow. For, though it be more difficult, than one would think, to ſettle any general rule about the riſing and falling of the quickſilver; yet in theſe parts, one of thoſe, that ſeem to hold oftneſt, is †, that when the high winds blow, the mercury is the lower; and yet that itſelf does ſometimes fail: for, this very day (*March* 3.) though on that hill, where I am, the ſomewhat weſterly winds have been bluſtering enough, yet ever ſince morning the quickſilver has been riſing, and is now riſen near $\frac{3}{8}$ of an inch.

I HAD thoughts to add ſomething about another kind of baroſcope (but inferiour to that in uſe) whereof I have given me intimation in one of the preliminaries to the *Hiſtory of Cold*. But you have already ſo much of a letter, and my occaſions, *&c.* to

THE ſame noble obſerver further intimates, That, as for that cauſe of the height of the quickſilver in droughts, which by him is ſuſpected to be the elevation of ſteams from the cruſt or ſuperficial parts of the earth, which by little and little may add to the weight of the atmoſphere, being not, as in other ſeaſons, carried down from time to time by the falling rain, it agrees not ill with what he has had ſince occaſion to obſerve. For, whereas about *March* 12th, at *Oxford*, the quickſilver was higher than, for aught he knew, had been yet obſerved in *England*, *viz.* above $\frac{1}{10}$ above thirty inches, upon the firſt conſiderable ſhowers, that have interrupted our long drought, as he affirms, he foretold divers hours before, that the quickſilver would be very low, (a bluſtering wind concurring with the rain) ſo he found it at *Stanton* to fall $\frac{3}{4}$ beneath 29 inches ‡.

* This hath been inquired into, and is found, that ſeveral accurate and curious perſons (as the moſt noble Preſident of the Royal Society, the Lord Viſcount *Brounker*, Doctor *Beale*, Mr. *Hook*, *&c.*) have obſerved the ſame.

† See *Num.* 1x. *Phil. Tranſact.* p. 157.—5, 8, 9. where the word *generally* ſignifies no more than *for the moſt part.*

‡ Dr. *Beale* concurs with this obſervation, when he ſaith, in a late letter of *March* 19. to his correſpondent in *London*: *By change of weather and wind, the mercury is ſunk more than an inch, ſince I wrote to you on* Monday *laſt*, March 12. *This laſt night, by rain and ſouth-wind, it is ſunk half an inch.*

THE

THE

ORIGIN

OF

FORMS and QUALITIES,

According to the CORPUSCULAR PHILOSOPHY;

Illuſtrated by CONSIDERATIONS and EXPERIMENTS.

Written formerly by Way of NOTES upon an ESSAY from NITRE.

Augmented by a DISCOURSE of SUBORDINATE FORMS.

Audendum eſt, & veritas inveſtiganda, quam etiamſi non aſſequamur, omnino tamen propriùs, quàm nunc ſumus, ad eam perveniemus. GALEN.

The PUBLISHER to the Ingenious READER.

IN this curious and inquiſitive age, when men, altogether diſſatisfied and wearied out with the wranglings and idle ſpeculations of the ſchools, are with equal zeal and induſtry ſo earneſt in their queſt and purſuit of a more ſolid, rational, and uſeful philoſophy, it may prove a work very obliging and meritorious to help and guide them in their ſtudies and reſearches, and to hang out a light to them, (as the *Egyptians* uſed to do from their highly celebrated *Pharos*, for direction to the mariners, that ſailed in thoſe dangerous ſeas near *Alexandria*) whereby they may with better ſucceſs ſteer their courſe through the vaſt ocean of learning, and make more full and perfect diſcoveries of hitherto unknown philoſophical verities: which has been the chief deſign of this gentleman of honour, the moſt excellent and incomparable author, in this treatiſe now preſented to your view, wherein principles are not (as was the mode and guiſe of former times) obtruded on the world upon the account of a great name, or involved in cloudy and myſtical notions, which put the underſtanding upon the wreck, and yet when, with all this labour and toil of the brain, they are at laſt known, prove impertinent and uſeleſs to the making out with ſatisfaction, or ſo much as tolerably, the ordinary phænomena, which nature every day preſents the world with; but ſuch as are built upon the firm and immoveable foundation of reaſon, ſenſe, and experience, plain and obvious, as well to the eye, as to the underſtanding, and no leſs accurate and certain in their application. And though the moſt noble author hath herein, for the main, eſpouſed the atomical philoſophy (corrected and purged from the wild fancies and extravagancies of the firſt inventors of it, as to the origin of the univerſe, and ſtill imbraced with ſo much kindneſs and tenderneſs by ſome pretenders, againſt which he hath ſo learnedly diſputed in his firſt part *Of the Uſefulneſs of Experimental Philoſophy*) in explicating the appearances; yet conſidering the ſeveral alterations and additions (the happy product of his penetrating judgment) made therein, I may not ſcruple to call it a new hypotheſis, peculiar to the author, made out by daily obſervations, familiar proofs and experiments, and by exact and eaſily practicable chymical proceſſes; whereby one of the moſt abſtruſe parts of natural philoſophy, the origin of forms and qualities, which ſo much vexed and puzzled the antients, and which, I would ſpeak with the leave of the *Carteſians*, their ingenious maſter durſt ſcarce venture upon, or at leaſt was unwilling to handle at large, is now fully cleared and become manifeſt: ſo that from this very eſſay we may well take hope, and joyfully expect to ſee the noble project of the famous *Verulam* (hitherto reckoned among the *Deſiderata*) receive its full and perfect accompliſhment; I mean a real, uſeful, and experimental phyſiology, eſtabliſhed and bottomed upon eaſy, true, and generally received principles. But I ſhall not foreſtal thy judgment either about the excellency of the author, or his ſubject, who hath ſo freely communicated to the world thoſe treaſures of learning, wherewith his mind is inriched, but ſhall ſoon refer you to the work itſelf, after I have given you theſe few advertiſements.

THE following diſcourſe (as is eaſily perceivable by divers paſſages thereof) being written ſeveral years ſince whole and intire,

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as now it is, I know not whether it will be worth while to intimate, that the author casually turning over of late a very recent chymical writer, found in one of his treatiſes (divers of which he never to this day read over) a part of the fifth experiment of the ſecond ſection; but, as he profeſſes (and ſure is like to be believed) he did not dream, that that chymiſt, or any other author whatſoever, had lighted on that part of the experiment, till a good while after he had made and examined that, among many others, concerning ſalts, as may be eaſily gueſſed by the peculiar uſes and applications he made of it. And though he had met with ſo unlikely an experiment in a writer, who, whether he deſerve it or no, has the ill fortune to be much accuſed of inſincerity, and ſome of whoſe more eaſy proceſſes our author (who yet is willing to ſpare his name, and ſeems to think his works not uſeleſs) could not find to ſucceed, he ſhould not have taken it upon his authority, no more than he is wont to take other proceſſes, divers of which he yet in the general ſuppoſes may be true upon the relation of other chymiſts, who, by blemiſhing their books by things untrue and juſtly ſuſpicious, are not to be relied on, nor much thanked by wary men. But it will probably appear leſs pertinent to add any thing further on this ſubject, than to take notice, that when the author had once conſented to the publication of the following papers, he ſeveral times wiſhed for an opportunity to make the experiments and obſervations, he now preſents to the publick, more full and compleat than they were when addreſſed to a private friend. But the contagion that drove him from the places where his accommodations for repeating experiments were, obliged him to apply himſelf to other ſtudies and imployments.

AND upon the ſame account, though he afterwards found many of his notes upon other parts of the eſſay of *Salt-petre*, and have lying by him divers papers concerning *ſenſible Qualities*, and *Senſation in general*, and the *Production of ſecond Qualities*, together with a collection of *Notes about occult Qualities*, and ſome other ſubjects of kin to thoſe of this book; yet having, upon the freſhly intimated occaſion, diverted his thoughts to other ſubjects, he will not ingage himſelf to put together and communicate his collections on theſe ſubjects by any publick promiſe.

FURTHERMORE, as the author has in the following diſquiſitions aimed not at the raiſing or abetting a faction in philoſophy, but at the diſcovery of the truth; ſo he is not ſo ſolicitous, what every ſort of reader will think of his attempts, (which it is eaſy to foreſee are not like to be overwelcome to the votaries of the ſchool-philoſophy) as to refuſe a compliance with the deſires of his friends, who have been long ſince very earneſt with him, not to ſpend that time in replies to particular perſons, which might be more uſefully imployed in purſuing further diſcoveries of nature by experiments. If he meet with any cogent and material objections againſt any of his chief opinions, he is enough a lover of truth, to be diſpoſed to think himſelf obliged by thoſe that ſhall ſhew him his miſtakes, and to take occaſion to reform them. But if nothing new or weighty be urged, he conſiders, that he lives in an age, wherein he has obſerved (even in his own caſe) that truth, if recommended by real experiments, will in time make their own way, and wherein live ſtore of ingenious men, who, for the main, approve the opinions, and probably will not diſlike the arguments he has propoſed; and who being more at leiſure than he to write polemical books, will not ſilently ſuffer what they judge truth to be triumphed over, or oppreſſed by thoſe, who, imploying uſually but ſcholaſtical arguments, may be confuted by anſwers of the like nature. And therefore he doubts not, but that ſome learned favourers of the corpuſcularian philoſophy (of which he hath endeavoured to make out thoſe parts, wherein they almoſt all agree) will be both able and willing to defend thoſe diſcoveries by rational diſputations, that they have not opportunity to increaſe by new experiment.

IN the mean while, I have no temptation to doubt in the leaſt, but that this curious and excellent piece will be entertained and received by all that have any regard to the great concerns of learning, with that guſt, delight, reſpect, and eſtimation, which it ſo highly merits.

The AUTHOR'S Prooemial Diſcourſe to the READER *.

AS it is the part of a mineraliſt, both to diſcover new mines, and to work thoſe, that are already diſcovered, by ſeparating and melting the ores to reduce them into perfect metal; ſo I eſteem, that it becomes a naturaliſt, not only to deviſe hypotheſes and experiments, but to examine and improve thoſe, that are already found out. Upon this conſideration, (among other motives) I was invited to make the following attempt, whoſe productions coming to be expoſed to other eyes, than thoſe, for which they were firſt written, it will be requiſite to give the publick ſome account of the occaſion, the ſcope, and ſome circumſtances. And this I ſhall do the more fully, becauſe the reaſons I am to render of my way of writing, in reference to the Peripatetick philoſophy, muſt contain intimations, which, perhaps, will not be uſeleſs to ſome ſorts of readers, (eſpecially gentlemen,) and, by being applied to moſt of thoſe other parts of my writings, that relate to the ſchool-philoſophy, may do them good ſervice, and ſave both my readers and me ſome trouble of repetitions.

HAVING

* The following preface being addreſſed only to *Pyraphilus*.

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The PUBLISHER *to the* READER.

HAVING four or five years ago publiſhed a little phyſico-chymical tract about the differing parts and red integration of nitre, I found as well by other ſigns, as by the early ſollicitations of the ſtationer for a new edition, that I had no cauſe to complain of the reception, that had been given it: but I obſerved too, that the diſcourſe, conſiſting chiefly of reflexions, that were occaſionally made upon the phænomena of a ſingle experiment, was more available to confirm thoſe in the Corpuſcularian philoſophy, that had already ſomewhat inquired into it, than to acquaint thoſe with the principles and notions of it, who were utter ſtrangers to it; and, as to many readers, was fitter to excite a curioſity for that philoſophy, than to give an introduction thereunto. Upon this occaſion it came into my mind, that about the time, when I writ that eſſay about ſalt-petre, (which was divers years before it was publiſhed) I had alſo ſome thoughts of a hiſtory of qualities, and that having in looſe ſheets ſet down divers obſervations and experiments proper for ſuch a deſign, I had alſo drawn up a diſcourſe, which was ſo contrived, that though ſome parts of it were written in ſuch a manner, as that they may ſerve for expoſitory notes upon ſome particular paſſages of the eſſay; yet thoſe parts with the reſt might ſerve for a general Preface to the hiſtory of qualities, in caſe I ſhould ever have conveniency, as well as inclination, to make the proſecuting of it my buſineſs; and in the mean time might preſent that *Pyrophilus*, to whom I writ ſome kind of introduction to the principles of the mechanical philoſophy, by expounding to him, as far as my thoughts and experiments would enable me to do, in few words, what, according to the Corpuſcularian notions, may be thought of the nature and origin of qualities and forms; the knowledge of which either makes or ſuppoſes the moſt fundamental and uſeful part of natural philoſophy. And to invite me to make uſe of theſe conſiderations and trials about qualities and forms, it opportunely happened, that though I could not find many of the notes written about particular qualities, (my looſe papers having been, during the late confuſions, much ſcattered by the many removes I had then occaſion to make;) yet when laſt winter, being urged to publiſh my Hiſtory of Cold, (which ſoon after came forth) I rumaged among my looſe papers, I found, that the ſeveral notes of mine, that he had met with under various heads, but yet all concerning the origin of forms and qualities, together with the preface addreſſed to *Pyrophilus*, (though written at diſtant times and places) had two or three years before, by the care of an induſtrious perſon, with whom I left them, been fairly copied out together, (which circumſtance I mention, that the reader may not wonder to find the following book not written uniformly in one continued tenour) excepting ſome experiments, which having been of my own making, it was not difficult for me to perfect, either out of my notes and memory, or (where I doubted their ſufficiency) by repeated trials. So that if the urgency, wherewith divers ingenious men preſſed the publication of my new experiments about cold, and my unwillingneſs to protract it, till the froſty ſeaſon, that was fitteſt to examine and prove them, were all paſt, had not prevailed with me to let thoſe obſervations be made publick the laſt winter, they might have been accompanied with the preſent eſſay of the *Origin of Qualities and Forms*, which may be premiſed to what I have written touching any of the particular qualities, ſince it contains experiments and conſiderations fit to be preliminary to them all.

BUT though I was by this means diverted from putting out the following treatiſe, at the ſame time with the Hiſtory of Cold, yet I was without much difficulty prevailed with not to alter my intentions of ſuffering it to come abroad; becauſe divers of my hiſtorical accounts of ſome particular qualities are to be reprinted, which may receive much light and confirmation by the things delivered in this preſent treatiſe about qualities and forms in general. To which inducement was added the perſuaſion of ſome ingenious perſons, who are pleaſed to confeſs their having received more information and ſatisfaction in theſe papers, than I durſt pretend to give them: though indeed the ſubject is ſo noble and ſo important, and does ſo much want the being illuſtrated by ſome diſtinct and experimental diſcourſe, that not only, if I did not ſuſpect my friends of partiality, I ſhould hope, that it may gratify many readers, and inſtruct more than a few; but ſuch as it is, I do not altogether deſpair, that it will prove neither unacceptable nor uſeleſs. And indeed the doctrines of forms and qualities, and generation, and corruption, and alteration, are wont to be treated of by ſcholaſtical philoſophers in ſo obſcure, ſo perplexed, and ſo unſatisfactory a way, and their diſcourſes upon theſe ſubjects do conſiſt ſo much more of logical and metaphyſical notions and niceties than of phyſical obſervations and reaſonings, that it is very difficult for any reader of but an ordinary capacity, to underſtand what they mean, and no leſs difficult for any intelligent and unprejudiced reader to acquieſce in what they teach: which is oftentimes ſo precarious and ſo contradictious to itſelf, that moſt readers, (without always excepting ſuch as are learned and ingenious) frighted by the darkneſs and difficulties, wherewith theſe ſubjects have been ſurrounded, do not ſo much as look after or read over theſe general and controverted matters, about which the ſchools make ſo much noiſe; but deſpairing to find any ſatisfaction in the ſtudy of them, betake themſelves immediately to that part of phyſicks, that treats of particular bodies. So that to theſe it will not be unacceptable to have any intelligible notions offered them of thoſe things, which, as they are wont to be propoſed, are not wont to be underſtood: though yet the ſubjects themſelves, if I miſtake not, may be juſtly reckoned not only amongſt the nobleſt and moſt important, but (in caſe

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caſe they be duly propoſed) among the uſefulleſt and moſt delightful ſpeculations, that belong to phyſicks.

I CONSIDER too, that among thoſe, that are inclined to that philoſophy, which I find I have been much imitated in calling Corpuſcularian, there are many ingenious perſons, eſpecially among the nobility and gentry, who having been firſt drawn to like this new way of philoſophy by the ſight of ſome experiments, which for their novelty or prettineſs they were much pleaſed with, or for their ſtrangeneſs they admired, have afterwards delighted themſelves to make or ſee variety of experiments, without having ever had the opportunity to be inſtructed in the rudiments or fundamental notions of that philoſophy, whoſe pleaſing or amazing productions have enamoured them of it. And as our *Pyrophilus*, for whom theſe notes were drawn up, did in ſome regards belong to this ſort of virtuoſi, ſo it is not impoſſible, but that ſuch readers, as he was then, will not be ſorry to meet with a treatiſe, wherein though my chief and proper buſineſs be the giving ſome account of the nature and origin of forms and qualities; yet by reaſon of the connection and dependance betwixt theſe and divers of the other principal things, that belong to the general part of phyſics, I have been obliged to touch upon ſo many other important points, that this tract may in ſome ſort exhibit a ſcheme of, or ſerve for an introduction into the elements of the Corpuſcularian philoſophy.

AND as thoſe readers, that have had the curioſity to peruſe what is commonly taught in the ſchools about forms, and generation, and corruption, and thoſe other things we have been mentioning, and have (as is uſual among ingenious readers) quitted the ſtudy of thoſe unſatisfactory intricacies with diſguſt, will not be diſpleaſed to find in our notes ſuch explications of thoſe things, as render them at leaſt intelligible; ſo it will not, perhaps, prove unacceptable to ſuch readers, to find thoſe matters, which the ſchools had interwoven with *Ariſtotle*'s doctrine, reconciled and accommodated to the notions of the corpuſcular phyſics.

IF it be ſaid, that I have left divers things unmentioned, which are wont to be largely treated of by the Ariſtotelians, and particularly have omitted the diſcuſſion of ſeveral queſtions, about which they are wont very ſolemnly and eagerly to contend; I readily acknowledge it to be true: but I anſwer further, that to do otherwiſe than I have done, were not agreeable to the nature of my deſign, as is declared in the preface to *Pyrophilus*; and that though moſt readers will not take notice of it, yet ſuch, as are converſant in that ſort of authors, will, I preſume, eaſily find, that I have not left them unconſulted, but have had the curioſity to reſort to ſeveral both of the more and of the leſs recent ſcholaſtical writers about phyſics, and to ſome of the beſt metaphyſicians to boot, that I might the better inform myſelf, both what their opinions are, and upon what arguments they are grounded. But as I found thoſe inquiries far more troubleſome than uſeful, ſo I doubt not, that my omiſſions will not much diſpleaſe that ſort of readers, for whoſe ſake chiefly it is, that theſe papers are permitted to be made publick. For if I ſhould increaſe the obſcurity of the things themſelves I treat of, by adding the ſeveral obſcurer comments (rather than explications) and the perplexed and contradictious opinions I have met with among ſcholaſtic writers, I doubt, that ſuch perſons, as I chiefly write for, would, inſtead of better comprehending what I ſhould ſo deliver, abſolutely forbear to read it. And there being many doctrines, to which number this we are ſpeaking of ſeems to belong, wherein the ſame innate light, or other arguments, that diſcover the truth, do likewiſe ſufficiently ſhew the erroneouſneſs of diſſenting opinions; I hope it may ſuffice to propoſe and eſtabliſh the notions, that are to be imbraced, without ſollicitouſly diſproving what cannot be true, if thoſe be ſo. And indeed there are many opinions and arguments of good repute in the ſchools, which do ſo intirely rely upon the authority of *Ariſtotle*, or ſome of his more celebrated followers, that where that authority is not acknowledged, to fall upon a ſolemn confutation of what has been ſo precariouſly advanced, were not only unneceſſary, but indiſcreet, even in a diſcourſe not confined to the brevity challenged by the nature of this of ours. And there are very many queſtions and controverſies, which, though hotly and clamorouſly contended about, and indeed pertinent and fit enough to be debated in their philoſophy, do yet ſo much ſuppoſe the truth of ſeveral of their tenets, which the new philoſophers reject; or are grounded upon technical terms or forms of ſpeaking, that ſuppoſe the truth of ſuch opinions; or are expreſſions, whereof we neither do nor need make any uſe; that to have inſerted ſuch debates into ſuch a diſcourſe as mine, would have been, not only tedious, but impertinent. As (for inſtance) thoſe grand diſputes, whether the four elements are endowed with diſtinct ſubſtantial forms, or have only their proper qualities inſtead of them? and whether they remain in mixed bodies, according to their forms, or according to their qualities? And whether the former or the latter of thoſe be or be not refracted? Theſe, I ſay, and divers other controverſies about the four elements and their manner of miſtion, are quite out of doors in their philoſophy, that acknowledge neither, that there are four elements, nor that cold, heat, dryneſs, and moiſture are, in the Peripatetic ſenſe, firſt qualities, or that there are any ſuch things, as ſubſtantial forms *in rerum naturâ*. And it made me the more unwilling to ſtuff theſe papers with any needleſs ſchool-controverſies, becauſe I found upon peruſal of ſeveral ſcholaſtic writers, (eſpecially the recenter, who may probably be ſuppoſed to be the moſt refined) that they do not always mean the ſame things by the ſame terms, but ſome imploy them in one ſenſe, others in another, and ſometimes the ſame writer uſes them in very different ſenſes, which I am obliged to take notice of, that ſuch readers as have conſulted

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conſulted ſome of thoſe authors, may not accuſe me of miſtaking or injuring ſome of the ſcholaſtical terms and notions he may meet with in theſe papers, when I have only imployed them in the ſenſe of other ſchool-writers, which I judged preferable. And this puts me in mind of intimating, that whereas, on the contrary, I ſometimes imployed variety of terms and phraſes to expreſs the ſame thing, I did it purpoſely, though perhaps to the prejudice of my own reputation, for the advantage of *Pyrophilus*; both I and others having obſerved, that the ſame unobvious notions being ſeveral ways expreſſed, ſome readers, even among the ingenioufer ſort of them, will take it up much better in one of thoſe expreſſions, and ſome in another.

But perhaps it will be wondered at, even by ſome of the new philoſophers, that diſſenting ſo much as I do from *Ariſtotle* and the ſchoolmen, I ſhould overlook or decline ſome arguments, which ſome very ingenious men think to be of very great force againſt the doctrine I oppoſe. But divers of theſe arguments being ſuch, as the Logicians call *ad hominem*, I thought I might well enough ſpare them. For I have obſerved *Ariſtotle* in his Phyſics to write very often in ſo dark and ambiguous a way, that it is far more difficult than one would think, to be ſure what his opinion was: and the unlearned and too frequently jarring gloſſes of his interpreters have often made the comment darker than the text; ſo that (though in moſt it be, yet) in divers caſes it is not eaſy (eſpecially without the expence of many words) to lay open the contradictions of the Peripatetick doctrine, beſides that the urging ſuch contradictions are oftentimes fitter to ſilence an unwary adverſary, than ſatisfy a wary and judicious reader; it being very poſſible, that a man may contradict himſelf in two ſeveral places of his works, and yet not be in both of them in the wrong. For one of his aſſertions, though inconſiſtent with the other, may yet be conſiſtent with truth. But this is not all I have to ſay on this occaſion. For beſides that having for many reaſons elſewhere mentioned, purpoſely forborn the reading of ſome very much, and, for aught I know, very juſtly eſteemed diſcourſes about general hypotheſes, it is very poſſible, that I may be a ſtranger to ſome of thoſe arguments: beſides this, I ſay, I confeſs I have purpoſely forborn to make uſe of others, which I have ſufficiently taken notice of. For ſome of thoſe ratiocinations would engage him, that ſhould imploy them, to adopt an hypotheſis or theory, in which perhaps I am not ſo thoroughly ſatisfied, and of which I do not conceive myſelf to have, on this occaſion, any neceſſity to make uſe: and accordingly I have forborn to imploy arguments, that are either grounded on, or ſuppoſe indiviſible corpuſcles called *atoms*, or any innate motion belonging to them; or that the eſſence of bodies conſiſts in extenſion, or that a vacuum is impoſſible; or that there are ſuch *globuli cæleſtes*, or ſuch a *materia ſubtilis*, as the Carteſians imploy to explicate moſt of the phænomena of nature. For theſe and divers other notions, I (who here write rather for the Corpuſcularians in general, than any party of them) thought it improper needleſly to take in, diſcourſing, either againſt thoſe, to whom theſe things appear as diſputable, as the Peripatetic tenets ſeem to me; or for to ſatisfy an ingenious perſon, whom it were not fair to impoſe upon with notions, that I did not myſelf think proper.

And on the like account I forbore ſuch arguments as thoſe, that ſuppoſe in nature and bodies inanimate, deſigns and paſſions proper to living, and perhaps peculiar to intelligent beings; and (ſuch as) ſome proofs, that are drawn from the theology of the ſchools; (which I wiſh leſs interwoven with *Ariſtotle*'s philoſophy.) For though there be ſome things, which ſeem to be of this ſort, (as arguments drawn from final cauſes in divers particulars, that concern animals,) which in a ſound ſenſe I not only admit, but maintain; yet ſince, as they are wont to be propoſed, they are liable enough to be queſtioned, I thought it expedient for my preſent deſign to pretermit them, as things, that I do not abſolutely need; though the imploying ſome of them would facilitate my taſk. And this I did the rather, becauſe I alſo forbear to anſwer arguments, that however vehemently and ſubtilly urged by many of the modern ſchoolmen of the Roman Catholick communion, are either confeſſedly, or at leaſt really built upon ſome theological tenets of theirs, which being oppoſed by the divines of other churches, and not left unqueſtioned by ſome acute ones of their own, would not be proper to be ſolemnly taken notice of by me, whoſe buſineſs in this tract is to diſcourſe of natural things as a naturaliſt, without invading the province of divines, by intermeddling with ſupernatural myſteries; ſuch as thoſe, upon which divers of the phyſico-theological tenets of the ſchoolmen, eſpecially about real qualities, and * the ſeparableneſs of accidents from ſubjects of inheſion, are manifeſtly, if not alſo avowedly grounded. But to return to the other things I was owning to have left unmentioned, notwithſtanding all that I have been ſaying, I readily acknowledge, that in ſome recent authors, that have been imbracers of the new philoſophy, I have met with ſome paſſages, that might well and pertinently be taken into the following diſcourſe, but that having been (as I formerly intimated) tranſcribed ſome years ago, I cannot now ſo conveniently alter it: which I am the leſs troubled at, becauſe theſe few additional arguments, thought fit to illuſtrate or confirm, being not neceſſary to make

* *Atque hæc ſententia* (of the diſtinction and ſeparableneſs of quantity from matter) *eſt omnino tenenda: quanquam enim non poſſit ratione naturali ſufficienter demonſtrari, tamen ex principiis theologiæ convincitur eſſe vera, maximè propter myſterium euchariſtiæ:* Suarez Diſp. Metaph. 40. p. m. 341. pauciſque interjectis,—*Prima ratio pro hac ſententia eſt, quia in myſterio euchariſtiæ Deus ſeparavit quantitatem à ſubſtantiis panis & vini,* &c. Et p. m. 342.—*Hæc reſponſio & ſententia* [Adverſariorum] *ſic explicata non poteſt facilè & evidenter impugnari, ſiſtendo in puro naturali; nihilominus tamen, partim ratione naturali, partim adjuncto myſterio ſufficientiſſimè improbatur.*

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make out what has been delivered, may ſafely be let alone, unleſs there happen (as it is not unlikely there may) an occaſion of reprinting theſe notes, with ſuch inlargements, as may make them the more fit to be an introduction into the corpuſcular philoſophy.

I HOPE then, upon the whole matter, that I have pitched upon that way, that was the moſt conducive to my deſign, partly by inſiſting only on thoſe opinions, whether true or falſe, which for their importance or difficulty ſeemed to deſerve to be particularly either explicated or diſproved; and partly by chuſing to imploy ſuch arguments, as I thought the cleareſt, and cogenteſt, and by their aſſuming the leaſt of any, ſeemed the eaſieſt to be vindicated from exceptions; without troubling myſelf to anſwer objections, that appeared rather to be drawn from metaphyſical or logical ſubtilties, or to be grounded upon the authority of men, than to be phyſical ratiocinations, founded upon experience, or the nature of the things under debate; eſpecially having, in the propoſal and confirmation of the truth, ſo laid the grounds, and intimated the ways of anſwering what is like to be colourably objected againſt it, that an ingenious man may well enough furniſh himſelf with weapons to defend the truth, out of the notions, hints, and experiments, wherewith in this tract care has been taken to accompany it. And my forbearing to proſecute ſome of the Peripatetick controverſies any further than I have done, will not, I hope, be blamed by them, that have obſerved as well as I, how much thoſe diſputes are wont to be lengthened by ſuch frivolous diſtinctions, as do not deſerve to be ſolemnly examined, eſpecially in ſuch a compendious treatiſe as ours. For an attentive reader needs not be much converſant with the writings of the modern Peripateticks, about ſuch ſubjects, as ſubſtantial forms, generation, corruption, *&c.* to take notice, that it is their cuſtom, when they find themſelves diſtreſſed by a ſolid argument, to endeavour to elude it by ſome pitiful diſtinction or other; which is uſually ſo groundleſs, and ſo unintelligible, or ſo nugatory, or ſo impertinent to the ſubject, or at leaſt ſo inſufficient for the purpoſe it is alledged for, that to vouchſafe it a ſollicitous confutation, might queſtion a writer's judgment with intelligent readers; who by ſuch inſignificant diſtinctions are ſatisfied of nothing ſo much, as that the framers of them had rather ſay (that which indeed amounts to) nothing, than not to ſeem to ſay ſomething. And of ſuch evaſions they may probably be emboldened to make uſe, by the practice of *Ariſtotle* himſelf, to whom ſuch obſcure and unſatisfactory diſtinctions are ſo familiar, that I remember one of his own commentators * (and he one of the moſt judicious) could not forbear, upon a certain text of his maſter's, to complain of it, and particularly to take notice, that that one diſtinction of *actu & potentia* runs through almoſt all *Ariſtotle*'s philoſophy, and is imployed to ſhift off thoſe difficulties he could not clearly explicate.

BY which nevertheleſs I would not be underſtood to cenſure or decry the whole Peripatetick philoſophy, much leſs to deſpiſe *Ariſtotle* himſelf; whoſe own writings give me ſometimes cauſe a little to wonder, to find ſome abſurdities ſo confidently fathered upon him by his ſcholaſtic interpreters. For I look upon *Ariſtotle* as one (though but as one amongſt many) of thoſe famed ancients, whoſe learning about *Alexander*'s time ennobled *Greece*; and I readily allow him moſt of the praiſes due to great wits, excepting thoſe, which belong to clear-headed naturaliſts. And I here declare once for all, that where in the following tract, or any other of my writings, I do indefinitely depreciate *Ariſtotle*'s doctrine, I would be underſtood to ſpeak of his phyſicks, or rather of the ſpeculative part of them, (for his hiſtorical writings concerning animals I much eſteem) nor do I ſay, that even theſe may not have their uſe among ſcholars, and even in univerſities, if they be retained and ſtudied with due cautions and limitations; (of which I have elſewhere ſpoken.)

BUT to reſume the diſcourſe, whence the Peripatetick diſtinctions tempted me to digreſs; by any thing I formerly ſaid, I would not in the leaſt diſparage thoſe excellent, and eſpecially thoſe modern authors, that have profeſſedly oppoſed the Ariſtotelian phyſicks: (ſuch as *Lucretius*, *Verulam*, *Baſſo*, *Des Cartes* and his followers, *Gaſſendus*, the two *Boots*, *Magnenus*, *Pemble*, *Helmont*,) nor be thought to have made no uſe of any of their cogitations or arguments. For though ſome of their books I could not procure, when I had occaſion to have recourſe to them; and though the weakneſs of my eyes diſcouraged me from peruſing thoſe parts of others, that concerned not the ſubject I was treating of, yet I hope I have been benefited by thoſe I have conſulted, and might have been more ſo, by the learned *Gaſſendus*'s little, but ingenious, *Syntagma Philoſophiæ Epicuri*, if I had more ſeaſonably been acquainted with it.

BUT whether we have treated of the nature and origin of forms and qualities in a more comprehenſive way than others; whether we have by new and fit ſimilitudes and examples, and other means, rendred it more intelligible than they have done; whether we have added any conſiderable number of notions and arguments, towards the compleating and confirming of the propoſed hypotheſis; whether we have with reaſon diſmiſſed arguments unfit to be relied on; and whether we have propoſed ſome notions and arguments ſo warily, as to keep them from being liable to

* The author here meant is the inquiſitive Peripatetick *Cabæus*, who in one place hath theſe words: *Ut hanc quæſtionem ſolvat, recurrit ad illam diſtinctionem ſibi valde familiarem, quâ utitur Ariſtoteles in tota ſua Philoſophia, quoties obviam habet aliquam gravem difficultatem, diſtinguit enim actu vel potentia*, &c. In another theſe:—*Quæ eſt diſtinctio quædam familiaris Ariſtoteli, quam applicat omnibus rebus, ubi difficultates urgent, & videtur iſtis vocibus quaſi fatali gladio omnes reſcindere difficultatis nodos; vix enim eſt difficultas, cui non putat ſe ſatisfacere diſtinguendo* actu & potentiâ.

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to exceptions or evaſions, whereto they were obnoxious as others have propoſed them; whether (I ſay) we have done all or any of theſe in the firſt or ſpeculative part of this treatiſe, we willingly leave the reader to judge. But in the ſecond or hiſtorical part of it, perhaps he will be invited to grant, that we have done that part of phyſicks we have been treating of ſome little ſervice; ſince by the lovers of real learning, it was very much wiſhed, that the doctrines of the new philoſophy (as it is called) were backed by particular experiments; the want of which I have endeavoured to ſupply, by annexing ſome, whoſe nature and novelty, I am made believe, will render them as well acceptable as inſtructive. For though, that I might not anticipate what belongs to other papers, I did not make the laſt ſection conſiſt of above a decad of them, and though, for the reaſons intimated in the advertiſements premiſed to them, I did not expreſly mention to *Pyrophilus* all that I could have told him about them; yet I have been careful ſo to chuſe them, and to interweave hints in delivering them, that a ſagacious reader, who ſhall have the curioſity to try them heedfully, and make reflections on the ſeveral phænomena, that in likelihood will occur to him, will (if I miſtake not) receive no contemptible information, as of ſome other things, ſo particularly about the nature of mixtions, (which I take to be one of the moſt important and uſeful, though neglected and ill underſtood, doctrines of the practical part of phyſicks) and may probably light upon more than he expects, or I have fully delivered, and perhaps too more than I foreſaw.

AND though ſome virtuoſi, more converſant perhaps with things than books, preſuming the decay of the Peripatetick philoſophy to be every where as great, as it is among them in *England*, may think, that a doctrine, which they look on as expiring, need not have been ſo ſolicitouſly confuted; yet thoſe, that know how deep rooting this philoſophy has taken (both elſewhere, and particularly) in thoſe academies, where it has flouriſhed for many ages, and in ſome of which it is, excluſively to the mechanical philoſophy, watered and fenced by their ſtatutes or their ſuperiours: and he, that alſo knows, how much more eaſy ſome (more ſubtile than candid) wits find it plauſibly to defend an error, than ingenuouſly to confeſs it, will not wonder, that I ſhould think, that a doctrine ſo advantaged, though it be too erroneous to be feared, is yet too conſiderable to be deſpiſed. And not to queſtion, whether ſeveral of thoſe, that moſt contemn the favourers of the Peripatetick hypotheſis, as the later diſcoveries have reduced them to reform it, be not the leaſt provided to anſwer their arguments; (not to queſtion this, I ſay,) there are divers of our adverſaries (miſled only by education, and morally harmleſs prejudices) who do ſo much deſerve a better cauſe, than that, which needs all their ſubtilty without being worthy of it, that I ſhall think more pains, than I have taken, very uſefully beſtowed, if my arguments and experiments prove ſo happy, as to undeceive perſons, whoſe parts, too unluckily confined to narrow and fruitleſs notions, would render them illuſtrious champions for the truths they are able ſo ſubtily to oppoſe; and who might queſtionleſs perform conſiderable things, if they imployed as much dexterity to expound the myſteries of nature, as the riddles of the ſchoolmen, and laid out their wit and induſtry to ſurmount the obſcurity of her works, inſtead of that of *Ariſtotle*'s.

THERE might be a few other particulars fit to be taken notice of in this preface, but finding, that I had already mentioned them in that, which I had addreſſed to *Pyrophilus*, my haſte makes me willing rather to refer the reader thither for them, than alter that, or lengthen this, (which I ſhould think much too long already, if it were not poſſible, that it may hereafter prove preliminary to more papers than theſe it is now premiſed to.) So that there remains but one advertiſement neceſſary to be given here, namely, that whereas in the following notes I ſeveral times ſpeak of the author of the eſſay of ſalt-petre, as of a third perſon, the occaſion of that was, that when theſe notes, and ſome about particular qualities, were written, I had a deſign to make two diſtinct ſorts of annotations upon that eſſay; in the former whereof (which now comes forth) I aſſumed the perſon of a Corpuſcularian, and diſcourſed at that rate. But I had thoughts too (in caſe God were pleaſed to grant me life and opportunity) to take a ſecond review both of the treatiſe itſelf, and of the notes on it, and on that occaſion to add what my riper thoughts and further experience might ſuggeſt unto me. And that in my animadverſions I might with the more freedom and conveniency add, explain, alter, and even retract, as I ſhould ſee cauſe, I thought it not amiſs to write them, as if they were made on the work of another. By which intimation the reader may be aſſiſted to gueſs, how much I intended in the following diſcourſe, (in which, as in the prefaces belonging to it, I play the Corpuſcularian) to reſerve myſelf the freedom of queſtioning and correcting, upon the deſigned review, any thing delivered in theſe notes; and how much more it was in them my deſign to bring *Pyrophilus* experiments and queries, to illuſtrate obſcure matters, than by haſty aſſertions to dogmatize about them.

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The PREFACE.

THE origin, *Pyrophilus*, and nature of the qualities of bodies, is a ſubject, that I have long looked upon as one of the moſt important and uſeful, that the naturaliſt can pitch upon for his contemplation. For the knowlege we have of the bodies without us, being for the moſt part fetched from the informations the mind receives by the ſenſes, we ſcarce know any thing elſe in bodies, upon whoſe account they can work upon our ſenſes, ſave their qualities: for as to the ſubſtantial forms, which ſome imagine to be in all natural bodies, it is not half ſo evident, that there are ſuch, as it is, that the wiſeſt of thoſe, that do admit them, confeſs, that they do not well know them *. And as it is by their qualities, that bodies act immediately upon our ſenſes, ſo it is by virtue of thoſe attributes likewiſe, that they act upon other bodies, and by that action produce in them, and oftentimes in themſelves, thoſe changes, that ſometimes we call alterations, and ſometimes generation or corruption.

AND it is chiefly by the knowledge, ſuch as it is, that experience (not art) hath taught us, of theſe differing qualities of bodies, that we are enabled, by a due application of agents to patients, to exerciſe the little empire, that we have either acquired or regained over the creatures. But I think not the contemplation of qualities more noble and uſeful, than I find it difficult; for what is wont to be taught us of qualities in the ſchools, is ſo ſlight and ill-grounded, that it may be doubted, whether they have not rather obſcured than illuſtrated the things they ſhould have explained. And I was quickly diſcouraged from expecting to learn much from them of the nature of divers particular qualities, when I found, that, except ſome few, which they tell you in general may be deduced (by ways they leave thoſe to gueſs at, that can,) from thoſe four qualities, they are pleaſed to call the firſt, they confeſs, that the reſt ſpring from thoſe forms of bodies, whoſe particular natures the judiciouſeſt of them acknowledge they cannot comprehend. And *Ariſtotle* himſelf not only doth (as we ſhall ſee anon) give us of quality in general, (which yet ſeems far more eaſily definable, than many a particular quality,) no other than ſuch a definition, as is as obſcure as the thing to be declared by it; but I obſerve, not without ſome wonder, that in his eight books of *Phyſicks*, where he profeſſedly treats of the general affections of natural things, he leaves out the doctrine of qualities; as after him *Magirus*, and divers other writers of the Peripatetick phyſiology, have done: which (by the way) I cannot but look upon as an omiſſion, ſince qualities do as well ſeem to belong to natural bodies generally conſidered, as place, time, motion, and thoſe other things, which upon that account are wont to be treated of in the general part of natural philoſophy. The moſt ingenious *Des Cartes* has ſomething concerning ſome qualities; but though, for reaſons elſewhere expreſſed, I have purpoſely forborn to peruſe his ſyſtem of philoſophy, yet I find by turning over the leaves, that he has left moſt of the other qualities untreated of; and of thoſe, that are more properly called ſenſible, he ſpeaks but very briefly and generally, rather conſidering what they do upon the organs of ſenſe, than what changes happen in the objects themſelves, to make them cauſe in us a perception ſometimes of one quality, and ſometimes of another. Beſides that his explications do many of them ſo depend upon his peculiar notions (of a *Materia ſubtilis*, *globuli ſecundi elementi*, and the like) and theſe, as it became ſo great a perſon, he has ſo interwoven with the reſt of his hypotheſis, that they can ſeldom be made uſe of, without adopting his whole philoſophy. *Epicurus* indeed, and his ſcholiaſt *Lucretius*, have given ſome good hints concerning the nature of ſome few qualities. But, beſides that even theſe explications are divers of them either doubtful or imperfect, or both, there are many other qualities, which are left for others to treat of. And this is the ſecond and main difficulty, which I find in inveſtigating the nature of qualities; namely, that whatever be to be thought of the general theories of *Ariſtotle*, or other philoſophers, concerning qualities, we evidently want that, upon which a theory, to be ſolid and uſeful, muſt be built; I mean, an experimental hiſtory of them. And this we ſo want, that except perhaps what mathematicians have done concerning ſounds, and the obſervations (rather than experiments) that our illuſtrious *Verulam* hath (in ſome few pages) ſaid of heat, in his ſhort *Eſſay de Formâ Calidi*; I know not any one quality, of which any author has yet given us an any thing competent hiſtory. Theſe things I mention to you, *Pyrophilus*, not at all to derogate from thoſe great men, whoſe deſign ſeems rather to have been to deliver principles and ſummaries of philoſophy, than to inſiſt upon particulars; but for this purpoſe, that ſince the nature of qualities is ſo beneficial a ſpeculation, my labours may not be looked upon as wholly uſeleſs, though I can contribute but a little to the clearing of it; and that ſince it is ſo abſtruſe a ſubject, I may be pardoned, if I ſometimes miſs the mark, and leave divers things uncompleated; that being but what ſuch great philoſophers have done before me.

BUT, *Pyrophilus*, before I proceed to give you my notes upon this part of our author's eſſay, that you may rightly underſtand my intention in them, it will be requiſite to give you three or four advertiſements.

AND firſt, whenever I ſhall ſpeak indefinitely of ſubſtantial forms, I would always be under-

* *Nego tibi ullam eſſe formam nobis notam plenè & planè; noſtramque ſcientiam eſſe umbram in ſole.* *Scaliger*, (of whoſe confeſſion to the ſame purpoſe more are cited hereafter.)

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underſtood to except the reaſonable ſoul, that is ſaid to inform the human body, which declaration I here deſire may be taken notice of once for all.

SECONDLY, Nor am I willing to treat of the origin of qualities in beaſts; partly becauſe I would not be ingaged to examine of what nature their ſouls are, and partly becauſe it is difficult in moſt caſes, (at leaſt for one, that is compaſſionate enough) either to make experiments upon living animals, or to judge what influence their life may have upon the change of qualities produced by ſuch experiments.

THIRDLY, The occaſion of the following reflections being only this, that our author, in that part of his eſſay concerning ſaltpetre, whereto theſe notes refer, does briefly intimate ſome notions about the nature and origin of qualities; you muſt not expect, that I, whoſe method leads me but to write ſome notes upon this and ſome other parts of this eſſay, ſhould make ſolemn or elaborate diſcourſes concerning the nature of particular qualities, and that I ſhould fully deliver my own apprehenſions concerning thoſe ſubjects. For, as I elſewhere ſufficiently intimate, that in theſe firſt notes I write as a Corpuſcularian, and ſet down thoſe things only, that ſeem to have a tendency to illuſtrate or countenance the notions or fancies implied in our author's eſſay; ſo I muſt here tell you, that I neither have now the leiſure, nor pretend to the ſkill to deliver fully the hiſtory, or to explicate particularly the nature of each ſeveral quality.

FOURTHLY, But I conſider, that the ſchools have of late much amuſed the world, with a way they have got of referring all natural effects to certain entities, that they call real qualities, and accordingly attribute to them a nature diſtinct from the modification of the matter they belong to, and in ſome caſes ſeparable from all matter whatſoever; by which means they have, as far forth as their doctrine is acquieſced in, made it thought needleſs or hopeleſs for men to imploy their induſtry, in ſearching into the nature of particular qualities, and their effects. As if (for inſtance) it be demanded, how ſnow comes to dazzle the eyes, they will anſwer, that it is by a quality of whiteneſs, that is in it, which makes all very white bodies produce the ſame effect: and if you aſk what this whiteneſs is, they will tell you no more in ſubſtance, than that it is a real entity, which denominates the parcel of matter, to which it is joined, white; and if you further inquire, what this real entity, which they call a quality, is, you will find, as we ſhall ſee anon, that they either ſpeak of it much after the ſame rate that they do of their ſubſtantial forms, (as indeed ſome of the moderneſt teach, that a quality affects the matter it belongs to *per modum formæ ſecundariæ*, as they ſpeak) or at leaſt they will not explicate it more intelligibly.

AND accordingly, if you further aſk them, how white bodies in general do rather produce this effect of dazzling the eyes, than green or blue ones, inſtead of being told, that the former ſort of bodies reflect outwards, and ſo to the eye, far more of the incident light than the latter; you ſhall perchance be told, that it is their reſpective natures ſo to act. By which way of diſpatching difficulties, they make it very eaſy to ſolve all the phænomena of nature in general, but make men think it impoſſible to explicate almoſt any of them in particular.

AND though the unſatisfactorineſs and barrenneſs of the ſchool-philoſophy have perſuaded a great many learned men, eſpecially phyſicians, to ſubſtitute the chymiſts three principles, inſtead of thoſe of the ſchools; and though I have a very good opinion of chymiſtry itſelf, as it is a practical art; yet as it is by chymiſts pretended to contain a ſyſtem of theorical principles of philoſophy, I fear it will afford but a very little ſatisfaction to a ſevere inquirer into the nature of qualities. For beſides that, as we ſhall more particularly ſee anon, there are many qualities, which cannot with any probability be deduced from any of the three principles; thoſe, that are aſcribed to one or other of them, cannot intelligibly be explicated, without recourſe to the more comprehenſive principles of the Corpuſcularian philoſophy: to tell us, for inſtance, that all ſolidity proceeds from ſalt, only informing us, (where it can plauſibly be pretended) in what material principle or ingredient that quality reſides, not how it is produced; for this doth not teach us, (for example) how water even in exactly-cloſed veſſels comes to be frozen into ice; that is, turned from a fluid to a ſolid body, without the acceſſion of a ſaline ingredient (which I have not yet found pretended, eſpecially glaſs being held impervious to ſalts.) Wherefore, *Pyrophilus*, I thought it might much conduce to the underſtanding the nature of qualities, to ſhew how they are generated; and by the ſame way, I hoped it might remove in ſome meaſure the obſtacle, that theſe dark and narrow theories of the Peripateticks and Chymiſts may prove to the advancement of ſolid and uſeful philoſophy. That then, which I chiefly aim at, is to make it probable to you by experiments, (which I think hath not yet been done,) that almoſt all ſorts of qualities, moſt of which have been by the ſchools either left unexplicated, or generally referred to I know not what incomprehenſible ſubſtantial forms, may be produced mechanically; I mean by ſuch corporeal agents, as do not appear either to work otherwiſe than by virtue of the motion, ſize, figure, and contrivance of their own parts, (which attributes I call the mechanical affections of matter, becauſe to them men willingly refer the various operations of mechanical engines:) or to produce the new qualities exhibited by thoſe bodies, their action changes, by any other way, than by changing the texture or motion, or ſome other mechanical affection of the body wrought upon. And this if I can in any paſſable meaſure do, though but in a general way, in ſome or other of each of theſe three ſorts, into which the Peripateticks are wont to divide the qualities of bodies, I hope I ſhall have done

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no uſeleſs piece of ſervice to natural philoſophy; partly by exciting you, and your learned friends, to inquire after more intelligible and ſatisfactory ways of explicating qualities, and partly by beginning ſuch a collection of materials towards the hiſtory of thoſe qualities, that I ſhall the moſt largely inſiſt on, as heat, colours, fluidity and firmneſs, as may invite you and other ingenious men to contribute alſo their experiments and obſervations to ſo uſeful a work, and thereby lay a foundation, whereon you, and perhaps I, may ſuperſtruct a more diſtinct and explicite theory of qualities, than I ſhall at preſent adventure at. And though I know, that ſome of the things my experiments tend to manifeſt, may likewiſe be confirmed by the more obvious phænomena of nature, yet I preſume you will not diſlike my chuſing to entertain you with the former, (though without at all deſpiſing, or ſo much as ſtrictly forbearing to imploy the latter,) becauſe the changes of qualities made by our experiments, will, for the moſt part, be more quick and conſpicuous; and the agents made uſe of to produce them, being of our own applying, and oftentimes of our own preparation, we may be thereby aſſiſted the better to judge of what they are, and to make an eſtimate of what it is they do.

CONSIDERATIONS

AND

EXPERIMENTS,

TOUCHING THE

ORIGIN of FORMS and QUALITIES.

The THEORICAL PART.

THAT, before I deſcend to particulars, I may, *Pyrophilus*, furniſh you with ſome general apprehenſion of the doctrine (or rather the hypotheſis) which is to be collated with, and to be either confirmed or diſproved by the hiſtorical truths, that will be delivered concerning particular qualities, (and forms;) I will aſſume the perſon of a Corpuſcularian, and here, at the entrance, give you (in a general way) a brief account of the hypotheſis it ſelf, as it concerns the origin of qualities (and forms;) and for diſtinction's ſake, I ſhall comprize it in the eight following particulars, which, that the whole ſcheme may be the better comprehended, and as it were ſurveyed under one proſpect, I ſhall do little more than barely propoſe them, that either ſeem evident enough by their own light, or may without prejudice have divers of their proofs reſerved for proper places in the following part of this treatiſe. And though there be ſome other particulars, to which the importance of the ſubjects, and the greatneſs of the (almoſt univerſal) prejudices, that lie againſt them, will oblige me immediately to annex (for the ſeaſonable clearing and juſtifying of them) ſome annotations; yet that they may, as little as I can, obſcure the coherence of the whole diſcourſe, as much of them as conveniently may be ſhall be included in [ ] paratheſes.

I. I AGREE with the generality of philoſophers ſo far, as to allow, that there is one catholick or univerſal matter common to all bodies, by which I mean a ſubſtance extended, diviſible, and impenetrable.

II. BUT becauſe this matter being in its own nature but one, the diverſity we ſee in bodies muſt neceſſarily ariſe from ſomewhat elſe, than the matter they conſiſt of. And ſince we ſee not, how there could be any change in matter, if all its (actual or deſignable) parts were perpetually at reſt among themſelves, it will follow, that to diſcriminate the catholick matter into variety of natural bodies, it muſt have motion in ſome or all its deſignable parts: and that motion muſt have various tendencies, that which is in this part of the matter tending one way, and that which is in that part tending another; as we plainly ſee, in the univerſe or general maſs of matter, there is really a great quantity of motion, and that variouſly determined, and that yet divers portions of matter are at reſt.

THAT there is local motion in many parts of matter is manifeſt to ſenſe, but how matter came by this motion was of old, and is ſtill hotly diſputed of: for the antient Corpuſcularian

cularian philoſophers, (whoſe doctrine in moſt other points, though not in all, we are the moſt inclinable to,) not acknowledging an author of the univerſe, were thereby reduced to make motion congenite to matter, and conſequently coeval with it. But ſince local motion, or an endeavour at it, is not included in the nature of matter, which is as much matter when it reſts, as when it moves; and ſince we ſee, that the ſame portion of matter may from motion be reduced to reſt, and after it hath continued at reſt, as long as other bodies do not put it out of that ſtate, may by external agents be ſet a moving again; I, who am not wont to think a man the worſe naturaliſt for not being an atheiſt, ſhall not ſcruple to ſay with an eminent philoſopher of old, whom I find to have propoſed among the Greeks that opinion (for the main) that the excellent *Des Cartes* has revived amongſt us, that the origin of motion in matter is from God; and not only ſo, but that thinking it very unfit to be believed, that matter barely put into motion, and then left to it ſelf, ſhould caſually conſtitute this beautiful and orderly world: I think alſo further, that the wiſe author of things did, by eſtabliſhing the laws of motion among bodies, and by guiding the firſt motions of the ſmall parts of matter, bring them to convene after the manner requiſite to compoſe the world, and eſpecially did contrive thoſe curious and elaborate engines, the bodies of living creatures, endowing moſt of them with a power of propagating their ſpecies. But though theſe things are my perſuaſions, yet becauſe they are not neceſſary to be ſuppoſed here, where I do not pretend to deliver any compleat diſcourſe of the principles of natural philoſophy, but only to touch upon ſuch notions, as are requiſite to explicate the origin of qualities and forms, I ſhall paſs on to what remains, as ſoon as I have taken notice, that local motion ſeems to be indeed the principal amongſt ſecond cauſes, and the grand agent of all that happens in nature: for though bulk, figure, reſt, ſituation, and texture do concur to the phænomena of nature, yet in compariſon of motion they ſeem to be, in many caſes, effects, and in many others, little better than conditions, or requiſites, or cauſes *ſine quibus non*, which modify the operation, that one part of matter by virtue of its motion hath upon another; as in a watch, the number, the figure, and coaptation of the wheels and other parts is requiſite to the ſhewing the hour, and doing the other things, that may be, performed by the watch; but till theſe parts be actually put into motion, all their other affections remain inefficacious. And ſo in a key, though it were too big or too little, or if its ſhape were incongruous to that of the cavity of the lock, it would be unfit to be uſed as a key, though it were put into motion; yet let its bigneſs and figure be never ſo fit, unleſs actual motion intervene, it will never lock or unlock any thing, as without the like actual motion, neither a knife nor razor will actually cut, how much ſoever their ſhape and other qualities may fit them to do ſo. And ſo brimſtone, what diſpoſition of parts ſoever it have to be turned into flame, would never be kindled, unleſs ſome actual fire, or other parcel of vehemently and variouſly agitated matter, ſhould put the ſulphureous corpuſcles into a very briſk motion.

III. THESE two grand and moſt catholic principles of bodies, matter and motion, being thus eſtabliſhed, it will follow, both that matter muſt be actually divided into parts, that being the genuine effect of variouſly determined motion, and that each of the primitive fragments, or other diſtinct and intire maſſes of matter, muſt have two attributes, its own magnitude, or rather ſize, and its own figure or ſhape. And ſince experience ſhews us (eſpecially that, which is afforded us by chymical operations, in many of which matter is divided into parts, too ſmall to be ſingly ſenſible,) that this diviſion of matter is frequently made into inſenſible corpuſcles or particles, we may conclude, that the minuteſt fragments, as well as the biggeſt maſſes of the univerſal matter, are likewiſe endowed each with its peculiar bulk and ſhape. For being a finite body, its dimenſions muſt be terminated and meaſurable: and though it may change its figure, yet for the ſame reaſon it muſt neceſſarily have ſome figure or other. So that now we have found out, and muſt admit three eſſential properties of each intire or undivided, though inſenſible part of matter; namely, magnitude, (by which I mean not quantity in general, but a determined quantity, which we in engliſh oftentimes call the ſize of a body) ſhape, and either motion or reſt, (for betwixt them two there is no mean:) the two firſt of which may be called inſeparable accidents of each diſtinct part of matter; inſeparable, becauſe being extended, and yet finite, it is phyſically impoſſible, that it ſhould be devoid of ſome bulk or other, and ſome determinate ſhape or other; and yet accidents, becauſe that whether or no the ſhape can by phyſical agents be altered, or the body ſubdivided, yet mentally both the one and the other may be done, the whole eſſence of matter remaining undeſtroyed.

WHETHER theſe accidents may not conveniently enough be called the moods or primary affections of bodies, to diſtinguiſh them from thoſe leſs ſimple qualities, (as colours, taſtes, and odours,) that belong to bodies upon their account; or whether, with the Epicureans, they may not be called the conjuncts of the ſmalleſt parts of matter, I ſhall not now ſtay to conſider; but one thing the modern ſchools are wont to teach concerning accidents, is too repugnant to our preſent doctrine, to be in this place quite omitted; namely, that there are in natural bodies ſtore of real qualities, and other real accidents, which not only are no moods of matter, but are real entities diſtinct from it, and, according to the doctrine of many modern ſchoolmen, may exiſt ſeparate from all matter whatſoever. To clear this point a little, we muſt take notice, that accident is among logicians and philoſophers

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phers uſed in two ſeveral ſenſes, for ſometimes it is oppoſed to the fourth predicable, (property,) and is then defined; That, which may be preſent or abſent without the deſtruction of the ſubject; as a man may be ſick or well, and a wall white or not white, and yet the one be ſtill a man, the other a wall: and this is called in the ſchools *accidens prædicabile*, to diſtinguiſh it from what they call *accidens prædicamentale*, which is oppoſed to ſubſtance: for when things are divided by logicians into ten predicaments or higheſt genus's of things, ſubſtance making one of them, all the nine other are of accidents. And as ſubſtance is commonly defined to be a thing, that ſubſiſts of itſelf, and is the ſubject of accidents, (or more plainly, a real entity or thing, that needs not any (created) being, that it may exiſt:) ſo an accident is ſaid commonly to be *id cujus eſſe eſt ineſſe*; and therefore *Ariſtotle*, who uſually calls ſubſtances ſimply ὄντα, *entities*, moſt commonly calls accidents ὄντων ὄντα, *entities of entities*; theſe needing the exiſtence of ſome ſubſtance or other, in which they may be, as in their ſubject of inheſion. And becauſe logicians make it the diſcriminating note of ſubſtance and accident, that the former is a thing, that cannot be in another, as in its ſubject of inheſion, it is requiſite to know, that, according to them, that is ſaid to be in a ſubject, which hath theſe three conditions; That however it (1) be in another thing, (2) is not in it as a part, and (3) cannot exiſt ſeparately from the thing or ſubject wherein it is: as a white wall is the ſubject of inheſion of the whiteneſs we ſee in it, which ſelf-ſame whiteneſs, though it be not in the wall as a part of it, yet cannot the ſelf-ſame whiteneſs, according to our logicians, exiſt any where out of the wall, though many other bodies may have the like degree of whiteneſs. This premiſed, it will not be hard to diſcover the falſity of the lately mentioned ſcholaſtick opinion touching real qualities, and accidents, their doctrine about which does, I confeſs, appear to me to be either unintelligible, or manifeſtly contradictious. For ſpeaking in a phyſical ſenſe, if they will not allow theſe accidents to be modes of matter, but entities really diſtinct from it, and in ſome caſes ſeparable from all matter, they make them indeed accidents in name, but repreſent them under ſuch a notion, as belongs only to ſubſtances; the nature of a ſubſtance conſiſting in this, that it can ſubſiſt of itſelf, without being in any thing elſe, as in a ſubject of inheſion. So that to tell us, that a quality, or other accident, may ſubſiſt without a ſubject, is indeed, whatever they pleaſe to call it, to allow it the true nature of ſubſtance; nor will their groundleſs diſtinctions do any more than keep them from ſeeming to contradict themſelves in words, whilſt unprépoſſeſſed perſons ſee, that they do it in effect. Nor could I ever find it intelligibly made out, what theſe real qualities may be, that they deny to be either matter or modes of matter, or immaterial ſubſtances. When a bowl runs along or lies ſtill, that motion or reſt, or globous figure of the bowl, is not nothing, and yet is not any part of the bowl; whoſe whole ſubſtance would remain, though it wanted which you pleaſe of theſe accidents: and to make them real and phyſical entities, (for we have not here to do either with logical or metaphyſical ones) is, as if, becauſe we may conſider the ſame man ſitting, ſtanding, running, thirſty, hungry, weary, &c. we ſhould make each of theſe a diſtinct entity, as we do give ſome of them (as hunger, wearineſs, &c.) diſtinct names. Whereas the ſubject of all theſe qualities is but the ſame man, as he is conſidered with circumſtances, that make him appear different in one caſe from what he appears in the other: and it may be very uſeful to our preſent ſcope to obſerve, that not only diverſity of names, but even diverſity of definitions, doth not always infer a diverſity of phyſical entities in the ſubject, whereunto they are attributed. For it happens in many of the phyſical attributes of a body, as in thoſe other caſes, wherein a man that is a father, a huſband, a maſter, a prince, &c. may have a peculiar definition (ſuch as the nature of the thing will bear) belong unto him in each of theſe capacities; and yet the man in himſelf conſidered is but the ſame man, who, in reſpect of differing capacities, or relations to other things, is called by differing names, and deſcribed by various definitions, which yet (as I was ſaying) conclude not ſo many real and diſtinct entities in the perſon ſo variouſly denominated.

An EXCURSION about the relative Nature of PHYSICAL QUALITIES.

BUT becauſe I take this notion to be of no ſmall importance towards the avoiding of the grand miſtake, that hath hitherto obtained about the nature of qualities, it will be worth while to illuſtrate it a little farther. We may conſider then, that when *Tubal-Cain*, or whoever elſe were the ſmith, that invented locks and keys, had made his firſt lock, (for we may reaſonably ſuppoſe him to have made that before the key, though the compariſon may be made uſe of without that ſuppoſition,) that was only a piece of iron, contrived into ſuch a ſhape; and when afterwards he made a key to that lock, that alſo in itſelf conſidered was nothing but a piece of iron of ſuch a determinate figure: but in regard, that theſe two pieces of iron might now be applied to one another after a certain manner, and that there was a congruity betwixt the wards of the

the lock and thoſe of the key, the lock and the key did each of them now obtain a new capacity, and it became a main part of the notion and deſcription of a lock, that it was capable of being made to lock or unlock by that piece of iron we call a key, and it was looked upon as a peculiar faculty and power in the key, that it was fitted to open and ſhut the lock, and yet by theſe new attributes there was not added any real or phyſical entity either to the lock or to the key, each of them remaining indeed nothing but the ſame piece of iron, juſt ſo ſhaped as it was before. And when our ſmith made other keys of differing bigneſſes, or with differing wards, though the firſt lock was not to be opened by any of thoſe keys, yet that indiſpoſition, however it might be conſidered as a peculiar power of reſiſting this or that key, and might ſerve to diſcriminate it ſufficiently from the locks thoſe keys belonged to, was nothing new in the lock, or diſtinct from the figure it had before thoſe keys were made. To carry this compariſon a little further, let me add, that though one, that would have defined the firſt lock and the firſt key, would have given them diſtinct definitions with reference to each other; and yet (as I was ſaying) theſe definitions being given but upon the ſcore of certain reſpects, which the defined bodies had one to another, would not infer, that theſe two iron inſtruments did phyſically differ otherwiſe than in the figure, ſize, or contrivement of the iron, whereof each of them conſiſted. And proportionably hereunto, I do not ſee, why we may not conceive, that as to thoſe qualities (for inſtance) which we call ſenſible, though, by virtue of a certain congruity or incongruity in point of figure or texture, (or other mechanical attributes) to our ſenſories, the portions of matter they modify are enabled to produce various effects, upon whoſe account we make bodies to be endowed with qualities; yet they are not in the bodies, that are endowed with them, any real or diſtinct entities, or differing from the matter itſelf, furniſhed with ſuch a determinate bigneſs, ſhape, or other mechanical modifications. Thus, though the modern goldſmiths and refiners reckon amongſt the moſt diſtinguiſhing qualities of gold, by which men may be certain of its being true and not ſophiſticated, that it is eaſily diſſoluble in aqua regis, and that aqua fortis will not work upon it; yet theſe attributes are not in the gold any thing diſtinct from its peculiar texture, nor is the gold we have now of any other nature than it was in *Pliny*'s time, when aqua fortis and aqua regis had not been found out (at leaſt in theſe parts of the world,) and were utterly unknown to the Roman goldſmiths. And this example I have the rather pitched upon, becauſe it affords me an opportunity to repreſent, that, unleſs we admit the doctrine I have been propoſing, we muſt admit, that a body may have an almoſt infinite number of new real entities accruing to it, without the intervention of any phyſical change in the body itſelf. As for example, gold was the ſame natural body immediately before aqua regis and aqua fortis were firſt made, as it was immediately after; and yet now it is reckoned amongſt its principal properties, that it is diſſoluble by the former of thoſe two menſtruums, and that it is not like other metals diſſoluble or corrodible by the latter. And if one ſhould invent another menſtruum, (as poſſibly I may think myſelf maſter of ſuch a one) that will but in part diſſolve pure gold, and change ſome part of it into another metalline body, there will then ariſe another new property, whereby to diſtinguiſh that from other mettals; and yet the nature of gold is not a whit other now, than it was before this laſt menſtruum was firſt made. There are ſome bodies not cathartick, nor ſudorifick, with ſome of which gold being joined, acquires a purgative virtue, and with others a power to procure ſweat; and, in a word, nature herſelf doth ſometimes otherwiſe, and ſometimes by chance produce ſo many things, that have new relations unto others: and art, eſpecially aſſiſted by chymiſtry, may, by variouſly diſſipating natural bodies, or compounding either them or their conſtituent parts with one another, make ſuch an innumerable company of new productions, that will each of them have new operations either immediately upon our ſenſories, or upon other bodies, whoſe changes we are able to perceive, that no man can know, but that the moſt familiar bodies may have multitudes of qualities, that he dreams not of, and a conſidering man will hardly imagine, that ſo numerous a croud of real phyſical entities can accrue to a body, whilſt in the judgment of all our ſenſes it remains unchanged, and the ſame, that it was before.

To clear this a little further, we may add, that beaten glaſs is commonly reckoned among poiſons; and (to ſkip what is mentioned out of *Sanctorius*, of the dyſentery procured by the fragments of it,) I remember * *Cardan* hath a ſtory, that in a cloiſter, where he had a patient then like to die of torments in the ſtomach, two other nuns had been already killed by a diſtracted woman, that having caſually got free, had mixed beaten glaſs with peas, that were eaten by theſe three, and divers others of the ſiſters (who yet eſcaped unharmed.) Now though the powers of poiſons be not only looked upon as real qualities, but are reckoned among the abſtruſeſt ones; yet this deleterious faculty, which is ſuppoſed to be a peculiar and ſuperadded entity in the beaten glaſs, is really nothing diſtinct from the glaſs itſelf, (which though a concrete made up of thoſe innocent ingredients, ſalt and aſhes, is yet a hard and ſtiff body,) as it is furniſhed with that determinate bigneſs, and figure of parts, which have been acquired by comminution. For theſe glaſſy fragments being many, and rigid, and ſomewhat ſmall, (without yet being ſo ſmall as duſt,) and endowed with ſharp points and cutting edges, are enabled by theſe mechanical affections to pierce or wound the tender membranes

* *Cardan. Contradict.* 9. lib. 2. Tract. 5. *apud Schenkium.*

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membranes of the ſtomach and guts, and cut the ſlender veſſels, that they may meet with there; whereby naturally enſue great gripings and contorſions of the injured parts, and oftentimes bloody fluxes occaſioned by the perforation of the capillary arteries, and the great irritation of the expulſive faculty, and ſometimes alſo not only horrid convulſions by conſent of the brain and cerebellum, with ſome of the nervous or membranous parts, that happen to be hurt, but alſo dropſies, occaſioned by the great loſs of blood we were juſt now ſpeaking of. And it agrees very well with this conjecture, that beaten glaſs hath divers times been obſerved to have done no miſchief to animals, that have ſwallowed it: for there is no reaſon it ſhould, in caſe the corpuſcles of the powder either chance to be ſo ſmall, as not to be fit to wound the guts, which are uſually lined with a ſlimy ſubſtance, wherein very minute powders may be as it were ſheathed, and by that means hindered from hurting the guts, (inſomuch that a fragment of glaſs with three very ſharp corners hath been obſerved to have for above eighteen months * lain inoffenſive even in a nervous and very ſenſible part of the body,) out of which they may, with the groſſer excrements of the lower belly, be harmleſly excluded, eſpecially in ſome individuals, whoſe guts and ſtomach too may be of a much ſtronger texture, and better lined or ſtuffed with groſs and ſlimy matter than thoſe of others. And accordingly we ſee, that the fragments of ſaphires, cryſtals, and even rubies, which are much harder than glaſs, are innocently, though perhaps not very effectually, uſed by phyſicians, (and I have ſeveral times taken that without inconvenience) in cordial compoſitions, becauſe of their being by grinding reduced to a powder too ſubtile to excoriate, or grate upon the ſtomach or guts; and probably it was upon ſome ſuch account, that that happened, which is related by *Cardan* in the ſame place; namely, that though the three nuns we have been ſpeaking of were poiſoned by the glaſs, yet many others, who eat of the other portions of the ſame mingled peas, received no miſchief thereby. (But of this ſubject more † elſewhere.)

AND this puts me in mind to add, that the multiplicity of qualities, that are ſometimes to be met with in the ſame natural bodies, needs not make men reject the opinion we have been propoſing, by perſuading them, that ſo many differing attributes, as may be ſometimes found in one and the ſame natural body, cannot proceed from the bare texture and other mechanical affections of its matter. For we muſt conſider each body, not barely as it is in itſelf, an intire and diſtinct portion of matter, but as it is a part of the univerſe, and conſequently placed among a great number and variety of other bodies, upon which it may act, and by which it may be acted on in many ways, (or upon many accounts,) each of which men are wont to fancy as a diſtinct power or quality in the body, by which thoſe actions, or in which thoſe paſſions are produced. For if we thus conſider things, we ſhall not much wonder, that a portion of matter, that is indeed endowed but with a very few mechanical affections, as ſuch a determinate texture and motion, but is placed among a multitude of other bodies, that differ in thoſe attributes from it and one another, ſhould be capable of having a great number and variety of relations to thoſe other bodies, and conſequently ſhould be thought to have many diſtinct inherent qualities, by ſuch as look upon thoſe ſeveral relations or reſpects it may have to bodies without it, as real and diſtinct entities implanted in the body itſelf. When a curious watch is going, though the ſpring be that, which puts all the parts into motion, yet we do not fancy (as an Indian or Chineſe would perchance do) in this ſpring one faculty to move the index uniformly round the dial-plate, another to ſtrike the hour, and perhaps a third to give an alarm, or ſhew the age of the moon, or the tides; all the action of the ſpring, (which is but a flexible piece of ſteel, forcibly coiled together,) being but an endeavour to dilate or unbind itſelf, and the reſt being performed by the various reſpects it hath to the ſeveral bodies (that compoſe the watch) among which it is placed, and which they have one to another. We all know, that the ſun hath a power to harden clay, and ſoften wax, and melt butter, and thaw ice, and turn water into vapours, and make air expand itſelf in weather-glaſſes, and contribute to blanch linen, and make the white ſkin of the face ſwarthy, and mowed graſs yellow, and ripen fruit, hatch the eggs of ſilk-worms, caterpillars, and the like inſects, and perform I know not how many other things, divers of which ſeem contrary effects; and yet theſe are not diſtinct powers or faculties in the ſun, but only the productions of its heat, (which itſelf is but the briſk, and confuſed local motion of the minute parts of a body) diverſified by the differing textures of the body, that it chances to work upon, and the condition of the other bodies, that are concerned in the operation. And therefore whether the ſun in ſome caſes have any influence at all diſtinct from its light and heat, we ſee, that all thoſe phænomena, we have thought fit to name, are producible by the heat of the common culinary fire duly applied and regulated. And ſo, to give an inſtance of another kind, when ſome years ſince, to try ſome experiments about the propagation of motion with bodies leſs capable of being battered by one another, than thoſe, that have been formerly imployed, I cauſed ſome ſolid balls of iron ſkilfully hardened and exquiſitely ſhaped and glazed, to be purpoſely made

* This memorable accident happened to a ſenator of *Berne*, who was cured by the experienced *Fabricius Hildanus*, that gives a long account of it to the learned *Horſtius*, among whoſe obſervations it is extant, (*Lib. 2. Obſerv.* 35.) who aſcribes the indolence of the part, whilſt uncompreſſed, to ſome ſlimy juice, (familiar enough to thoſe tendinous parts,) wherein the glaſſy fragment was as it were bedded.

† In thoſe notes about Occult Qualities, where the deleterious faculty attributed to diamonds is conſidered.

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made; each of theſe poliſhed balls was a ſpherical looking-glaſs, which, placed in the midſt of a room, would exhibit the images of the objects round about it, in a very regular and pleaſing perſpective. It would contract the image, and reflect the beams of the ſun after a manner differing from flat and from convex looking-glaſſes. It would in a neat perſpective leſſen the image of him, that looked upon it, and bent it, and it would ſhew, that image, as if it were behind the ſurface, and within the ſolid ſubſtance of the ſphere; and in ſome it had all thoſe diſtinct, and ſome of them wonderful properties, which either ancient or modern writers of catoptricks have demonſtrated to belong to ſpherical ſpecula, as ſuch: and yet the globe, furniſhed with all theſe properties and affections, was but the iron itſelf reduced by the artificer to a ſpherical figure; (for the glaſs, that made it ſpecular, was not diſtinct from the ſuperficial parts of the iron, reduced all of them to a phyſically equal diſtance from the center.) And of ſpecula, ſpherical enough as to ſenſe, you may make ſtore in a trice, by breaking a large drop of quick-ſilver into ſeveral little ones, each of which will ſerve for objects placed pretty near it, and the ſmaller of which, (being the leaſt depreſſed in the middle by their own weight, and conſequently more perfectly globous,) may with a good microſcope placed in a window, afford you no unpleaſant proſpect of the neighbouring objects; and yet to reduce a parcel of ſtagnant quick-ſilver, which will much emulate a flat looking-glaſs, into many of theſe little ſpherical ſpecula, whoſe properties are ſo differing from thoſe of plain ones, there intervenes nothing but a ſlight local motion, which, in the twinkling of an eye, changeth the figure of the ſelf-ſame matter.

I HAVE ſaid thus much, *Pyrophilus*, to remove the miſtake, that every thing men are wont to call a quality, muſt needs be a real and phyſical entity, becauſe of the importance of the ſubject; and yet I have omitted ſome things, that might have been pertinently added, partly becauſe I may hereafter have opportunity to take them in, and partly becauſe I would not any farther lengthen this excurſion, which yet I muſt not conclude, till I have added this ſhort advertiſement.

THAT I have choſen to declare what I mean by qualities, rather by examples, than definitions, partly becauſe being immediately or reductively the objects of ſenſe, men generally underſtand pretty well what one another mean, when they are ſpoken of: as to ſay, that the taſte of ſuch a thing is ſaline or ſour, or that ſuch a ſound is melodious, ſhrill, or jarring, (eſpecially if, when we ſpeak of ſenſible qualities, we add ſome enumeration of particular ſubjects, wherein they do the moſt eminently reſide,) will make a man as ſoon underſtood, as if he ſhould go about to give logical definitions of thoſe qualities: and partly becauſe the notions of things are not yet ſo well ſtated and agreed on, but that it is many times difficult to aſſign their true genus's. And *Ariſtotle* himſelf doth not only define accidents without ſetting down their genus, but when he comes to define qualities, he tells us, that quality is that, by which a thing is ſaid to be *qualis*; where I would have you take notice, both, that in his definition he omits the genus, and that it is no ſuch eaſy thing to give a very good definition of qualities, ſince he, that is reputed the great maſter of logick, where he pretends to give us one, doth but upon the matter define the thing by the ſame thing: for it is ſuppoſed to be as little known what *qualis* is, as what *qualitas* is; and methinks he does juſt as if I ſhould define whiteneſs to be that, for which a thing is called white, or virtue that, for which a man is ſaid to be virtuous *. Beſides that, I much doubt, whether his definition be not untrue as well as obſcure: for to the queſtion, *Qualis res eſt?* anſwer may be returned out of ſome, if not all, of the other predicaments of accidents: which ſome of the modern logicians being aware of, they have endeavoured to ſalve the matter with certain cautions and limitations, which, however they may argue the deviſers to be ingenious, do, for aught I can diſcern, leave us ſtill to ſeek for a right and intelligible definition of quality in general; though to give ſuch a one be probably a much eaſier taſk, than to define many qualities, that may be named in particular, as ſaltneſs, ſourneſs, green, blue, and many others, which when we hear named, every man knows what is meant by them, though no man (that I know of) hath been able to give accurate definitions of them.

IV. AND if we ſhould conceive, that all the reſt of the univerſe were annihilated, except any of theſe intire and undivided corpuſcles, (treated of in the 3d particular foregoing,) it is hard to ſay what could be attributed to it, beſides matter, motion, (or reſt,) bulk, and ſhape. Whence by the way you may take notice, that bulk, though uſually taken in a comparative ſenſe, is in our ſenſe an abſolute thing, ſince a body would have it, though there were no other in the world. But now there being actually in the univerſe, great multitudes of corpuſcles mingled among them-

* Since the writing of this, the author found, that ſome of the eminenteſt of the modern ſchoolmen themſelves have been as well as he unſatisfied with the Ariſtotelian definition of quality: concerning which (not to mention *Rubius*, a learned Proteſtant annotator upon *Suarez*) *Ariaga* ſays (*diſp. 5. ſect. 2. ſubſ. 1.*) *Per hanc nihil explicatur; nam de hoc quærimus, quid ſit eſſe quale, dices habere qualitatem; bonus circulus: qualitas eſt id, quo quis ſit qualis, & eſſe qualem eſt habere qualitatem.* And even the famous Jeſuit *Suarez*, though he endeavours to excuſe it, yet confeſſeth, that it leaves the proper notion of quality as obſcure to us as before: (*Quæ definitio*, ſaith he, *licèt ea ratione eſſentialis videatur, quod detur per habitudinem ad effectum formalem, quem omnis forma eſſentialiter reſpicit, tamen quod ad nos ſpectat, æquè obſcura nobis manet propria ratio qualitatis.*) *Suarez diſputat. metaphyſ* 42. But *Hurtadus* (in his metaphyſical diſputations) ſpeaks more boldly, telling us roundly, that it is *non tam definitio, quàm inanis quædam negatio*; which makes me the more wonder, that a famous Carteſian (whom I forbear to name) ſhould content himſelf to give us ſuch an inſignificant or at leaſt ſuperficial definition of quality.

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themſelves, there ariſe in any diſtinct portion of matter, which a number of them make up, two new accidents or events: the one doth more relate to each particular corpuſcle in reference to the (really or ſuppoſedly) ſtable bodies about it, namely its poſture; (whether erected, inclined, or horizontal:) and when two or more of ſuch bodies are placed one by another, the manner of their being ſo placed, as one beſides another, or one behind another, may be called their order; as I remember, *Ariſtotle* in his Metaphyſicks, *lib.* 1. *cap.* 4. recites this example out of the ancient Corpuſcularians, that A and N differ in figure, and A N and N A in order, Z and N in ſituation: and indeed poſture and order ſeem both of them reducible to ſituation. And when many corpuſcles do ſo convene together, as to compoſe any diſtinct body, as a ſtone, or a metal, then from their other accidents (or modes,) and from theſe two laſt mentioned there doth emerge a certain diſpoſition or contrivance of parts in the whole, which we may call the texture of it.

V. AND if we ſhould conceive all the reſt of the univerſe to be annihilated, ſave one ſuch body, ſuppoſe a metal or a ſtone, it were hard to ſhew, that there is phyſically any thing more in it than matter, and the accidents we have already named. But now we are to conſider, that there are *de facto* in the world, certain ſenſible and rational beings, that we call men; and the body of man having ſeveral external parts, as the eye, the ear, *&c.* each of a diſtinct and peculiar texture, whereby it is capable to receive impreſſions from the bodies about it, and upon that account it is called an organ of ſenſe, we muſt conſider, I ſay, that theſe ſenſories may be wrought upon by the figure, ſhape, motion, and texture of bodies without them after ſeveral ways, ſome of thoſe external bodies being fitted to affect the eye, others the ear, others the noſtrils, *&c.* And to theſe operations of the objects on the ſenſories, the mind of man, which upon the account of its union with the body, perceives them, giveth diſtinct names, calling the one light or colour, the other ſound, the other odour, *&c.* And becauſe alſo each organ of ſenſe, as the eye, or the palate, may be itſelf differingly affected by external objects, the mind likewiſe gives the objects of the ſame ſenſe diſtinct appellations, calling one colour green, the other blue, and one taſte ſweet, and another bitter, *&c.* Whence men have been induced to frame a long catalogue of ſuch things, as, for their relating to our ſenſes, we call ſenſible qualities; and becauſe we have been converſant with them before we had the uſe of reaſon, and the mind of man is prone to conceive almoſt every thing (nay, even privations, as blindneſs, death, *&c.*) under the notion of a true entity or ſubſtance, as itſelf is; we have been from our infancy apt to imagine, that theſe ſenſible qualities are real beings, in the objects they denominate, and have the faculty or power to work ſuch and ſuch things; as gravity hath a power to ſtop the motion of a bullet ſhot upwards, and carry that ſolid globe of matter toward the center of the earth; whereas indeed (according to what we have largely ſhewn above) there is in the body, to which theſe ſenſible qualities are attributed, nothing of real and phyſical, but the ſize, ſhape, and motion, or reſt, of its component particles, together with that texture of the whole, which reſults from their being ſo contrived as they are; nor is it neceſſary they ſhould have in them any thing more, like to the ideas they occaſion in us; thoſe ideas being either the effects of our prejudices or inconſiderateneſs, or elſe to be fetched from the relation, that happens to be betwixt thoſe primary accidents of the ſenſible object, and the peculiar texture of the organ it affects: As when a pin, being run into my finger, cauſeth pain, there is no diſtinct quality in the pin anſwerable to what I am apt to fancy pain to be, but the pin in itſelf is only ſlender, ſtiff, and ſharp, and by thoſe qualities happens to make a ſolution of continuity in my organ of touching, upon which, by reaſon of the fabrick of the body, and the intimate union of the ſoul with it, there ariſeth that troubleſome kind of perception which we call pain, and I ſhall anon more particularly ſhew, how much that depends upon the peculiar fabrick of the body.

VI. BUT here I foreſee a difficulty, which being perhaps the chiefeſt, that we ſhall meet with againſt the corpuſcular hypotheſis, it will deſerve to be, before we proceed any farther, taken notice of. And it is this, that whereas we explicate colours, odours, and the like ſenſible qualities by a relation to our ſenſes, it ſeems evident, that they have an abſolute being irrelative to us: for ſnow (for inſtance) would be white, and a glowing coal would be hot, though there were no man or any other animal in the world. And it is plain, that bodies do not only by their qualities work upon our ſenſes, but upon other, and thoſe, inanimate bodies; as the coal will not only heat or burn a man's hand if he touch it, but would likewiſe heat wax, (even ſo much as to melt it and make it flow,) and thaw ice into water, although all the men and ſenſitive beings in the world were annihilated. To clear this difficulty, I have ſeveral things to repreſent: and,

1. I SAY not, that there are no other accidents in bodies than colours, odours, and the like; for I have already taught, that there are ſimpler and more primitive affections of matter, from which theſe ſecondary qualities, if I may ſo call them, do depend: and that the operations of bodies upon one another ſpring from the ſame, we ſhall ſee by and by.

2. Nor do I ſay, that all qualities of bodies are directly ſenſible; but I obſerve, that when one body works upon another, the knowledge we have of their operation proceeds either from ſome ſenſible quality, or ſome more catholick affection of matter, as motion, reſt, or texture, generated or deſtroyed in one of them; for elſe it is hard to conceive, how we ſhall come to diſcover what paſſes betwixt them.

3. WE

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3. We muſt not look upon every diſtinct body, that works upon our ſenſes, as a bare lump of matter of that bigneſs and outward ſhape, that it appears of; many of them having their parts curiouſly contrived, and moſt of them perhaps in motion too. Nor muſt we look upon the univerſe that ſurrounds us as upon a moveleſs and undiſtinguiſhed heap of matter, but as upon a great engine, which having either no vacuity, or none that is conſiderable betwixt its parts (known to us,) the actions of particular bodies upon one another muſt not be barely eſtimated, as if two portions of matter of their bulk and figure were placed in ſome imaginary ſpace beyond the world, but as being ſcituate in the world, conſtituted as it now is, and conſequently as having their action upon each other liable to be promoted or hindred or modified by the actions of other bodies beſides them: as in a clock, a ſmall force applied to move the index to the figure of XII; will make the hammer ſtrike often and forcibly againſt the bell, and will make a far greater commotion among the wheels and weights, than a far greater force would do, if the texture and contrivance of the clock did not abundantly contribute to the production of ſo great an effect. And in agitating water into froth, the whiteneſs would never be produced by that motion, were it not that the ſun, or other lucid body, ſhining upon that aggregate of ſmall bubbles, enables them to reflect confuſedly great ſtore of little and as it were contiguous lucid images to the eye. And ſo the giving to a large metalline ſpeculum a concave figure, would never enable it to ſet wood on fire, and even to melt down metals readily, if the ſun-beams, that in cloudleſs days do, as to ſenſe, fill the air, were not; by the help of that concavity, thrown together to a point. And to ſhew you by an eminent inſtance, how various and how differing effects the ſame action of a natural agent may produce, according to the ſeveral diſpoſitions of the bodies it works upon, do but conſider, that in two eggs, the one prolifick, the other barren, the ſenſe can perhaps diſtinguiſh before incubation no difference at all; and yet theſe bodies, outwardly ſo like, do ſo differ in the internal diſpoſition of their parts, that if they be both expoſed to the ſame degree of heat, (whether of a hen, or an artificial oven,) that heat will change the one into a putrid and ſtinking ſubſtance, and the other into a chick, furniſhed with great variety of organical parts of very differing conſiſtences, and curious as well as differing textures.

4. I Do not deny, but that bodies may be ſaid, in a very favourable ſenſe, to have thoſe qualities we call ſenſible, though there were no animals in the world: for a body in that caſe may differ from thoſe bodies, which now are quite devoid of quality, in its having ſuch a diſpoſition of its conſtituent corpuſcles, that in caſe it were duly applied to the ſenſory of an animal, it would produce ſuch a ſenſible quality, which a body of another texture would not: as though if there were no animals, there would be no ſuch thing as pain, yet a pin may, upon the account of its figure, be fitted to cauſe pain, in caſe it were moved againſt a man's finger; whereas a bullet, rother blunt body, moved againſt it with no greater force, will not cauſe any ſuch perception of pain. And thus ſnow, though if there were no lucid body nor organ of ſight in the world, it would exhibit no colour at all, (for I could not find it had any in places exactly darkened;) yet it hath a greater diſpoſition than a coal or ſoot, to reflect ſtore of light outwards, when the ſun ſhines upon them all three. And ſo we ſay, that a lute is in tune, whether it be actually played upon or no, if the ſtrings be all ſo duly ſtretched, as that it would appear to be in tune, if it were played upon. But as if you ſhould thruſt a pin into a man's finger, both a while before and after his death, though the pin be as ſharp at one time as at another, and maketh in both caſes alike a ſolution of continuity; yet in the former caſe the action of the pin will produce pain, and not in the latter, becauſe in this the pricked body wants the ſoul, and conſequently the perceptive faculty: ſo if there were no ſenſitive beings, thoſe bodies, that are now the objects of our ſenſes, would be but diſpoſitively, if I may ſo ſpeak, endowed with colours, taſtes, and the like; and actually but only with thoſe more catholick affections of bodies, figure, motion, texture, *&c.*

To illuſtrate this yet a little farther: ſuppoſe a man ſhould beat a drum at ſome diſtance from the mouth of a cave, conveniently ſituated to return the noiſe he makes; although men will preſently conclude, that that cave hath an echo, and will be apt to fancy upon that account ſome real property in the place, to which the echo is ſaid to belong; and although indeed the ſame noiſe, made in many other of the neighbouring places, would not be reflected to the ear, and conſequently would manifeſt thoſe places to have no echos; yet to ſpeak phyſically of things, this peculiar quality or property we fancy in the cave, is in it nothing elſe but the hollowneſs of its figure, whereby it is ſo diſpoſed, as when the air beats againſt it, to reflect the motion towards the place whence that motion began; and that, which paſſeth on this occaſion, is indeed but this, that the drum-ſtick falling upon the drum makes a percuſſion of the air, and puts that fluid body into an undulating motion, and the airy waves thruſting on one another, till they arrive at the hollow ſuperficies of the cave, have, by reaſon of its reſiſtance and figure, their motion determined the contrary way; namely, backwards towards that part, where the drum was, when it was ſtruck. So that in that, which here happens, there intervenes nothing but the figure of one body, and the motion of another; though if a man's ear chance to be in the way of theſe motions of the air forwards and backwards, it gives him a perception of them, which he calls ſound. And becauſe theſe perceptions, which are ſuppoſed to proceed

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ceed from the ſame percuſſion of the drum, and thereby of the air, are made at diſtinct times one after another, that hollow body, from whence the laſt ſound is conceived to come to the air, is imagined to have a peculiar faculty, upon whoſe account men are wont to ſay, that ſuch a place hath an echo.

5. AND whereas one body doth often ſeem to produce in another divers ſuch qualities, as we call ſenſible, which qualities therefore ſeem not to need any reference to our ſenſes; I conſider, that when one inanimate body works upon another, there is nothing really produced by the agent in the patient, ſave ſome local motion of its parts, or ſome change of texture conſequent upon that motion: and ſo, if the patient come to have any ſenſible quality, that it had not before, it acquires it upon the ſame account, upon which other bodies have it, and it is but a conſequent to this mechanical change of texture, that by means of its effects upon our organs of ſenſe, we are induced to attribute this or that ſenſible quality to it. As in caſe a pin ſhould chance by ſome inanimate body to be driven againſt a man's finger, that, which the agent doth, is but to put a ſharp and ſlender body into ſuch a kind of motion; and that which the pin doth, is to pierce into a body, that it meets with, not hard enough to reſiſt its motion; and ſo that upon this there ſhould enſue ſuch a thing as pain, is but a conſequent, that ſuperadds nothing of real to the pin, that occaſions that pain. So if a piece of tranſparent ice be, by the falling of ſome heavy and hard body upon it, broken into a groſs powder, that looks whitiſh, the falling body doth nothing to the ice but break it into very ſmall fragments, lying confuſedly upon one another; though by reaſon of the fabrick of the world, and of our eyes, there doth in the day-time upon this comminution enſue ſuch a kind of copious reflection of the incident light to our eyes, as we call whiteneſs. And when the ſun, by thawing this broken ice, deſtroys the whiteneſs of that portion of matter, and makes it become diaphanous, which it was not before, it doth no more than alter the texture of the component parts, by putting them into motion, and thereby into a new order; in which, by reaſon of the diſpoſition of the pores intercepted betwixt them, they reflect but few of the incident beams of light, and tranſmit moſt of them. Thus when with a burniſher you poliſh a rough piece of ſilver, that which is really done, is but the depreſſion of the little protuberant parts into one level with the reſt of the ſuperficies; though upon this mechanical change of the texture of the ſuperficial parts, we men ſay, that it hath loſt the quality of roughneſs, and acquired that of ſmoothneſs; becauſe that, whereas before the little exſtancies by their figure reſiſted a little the motion of our fingers, and grated upon them a little, our fingers now meet with no ſuch offenſive reſiſtance. It is true, that the fire doth thaw ice, and alſo both make wax flow, and enable it to burn a man's hand; and yet this doth not neceſſarily argue in it any inherent quality of heat, diſtinct from the power it hath of putting the ſmall parts of the wax into ſuch a motion, as that their agitation ſurmounts their coheſion; which motion, together with their gravity, is enough to make them *pro tempore* conſtitute a fluid body; and aqua fortis, without any (ſenſible) heat, will make camphire caſt on it aſſume the form of a liquor diſtinct from it; as I have tried, that a ſtrong fire will alſo make camphire fluid: not to add, that I know a liquor into which certain bodies being put, when both itſelf (as well as they) is actually cold, (and conſequently when you would not ſuſpect it of an actual inherent heat) will not only ſpeedily diſſipate many of their parts into ſmoke, but leave the reſt black, and burnt almoſt like a coal. So that though we ſuppoſe the fire to do no more than variouſly and briſkly to agitate the inſenſible parts of the wax, that may ſuffice to make us think the wax endowed with a quality of heat: becauſe if ſuch an agitation be greater than that of the ſpirit, and other parts of our organs of touching, that is enough to produce in us that ſenſation we call heat; which is ſo much a relative to the ſenſory which apprehends it, that we ſee, that the ſame lukewarm water, that is, whoſe corpuſcles are moderately agitated by the fire, will appear hot to one of a man's hands, if that be very cold, and cold to the other, in caſe it be very hot, though both of them be the ſame man's hands. To be ſhort, if we fancy any two of the bodies about us, as a ſtone, a metal, *&c.* to have nothing at all to do with any other body in the univerſe, it is not eaſy to conceive either how one can act upon the other, but by local motion (of the whole body, or its corporeal effluvia;) or how by motion it can do any more than put the parts of the other body into motion too, and thereby produce in them a change of ſituation and texture, or of ſome other of its mechanical affections: though this (paſſive) body being placed among other bodies in a world conſtituted as ours now is, and being brought to act upon the moſt curiouſly contrived ſenſories of animals, may upon both theſe accounts exhibit many differing ſenſible phænomena; which however we look upon them as diſtinct qualities, are conſequently but the effects of the often mentioned catholick affections of matter, and deducible from the ſize, ſhape, motion (or reſt,) poſture, order, and the reſulting texture of the inſenſible parts of bodies. And therefore though, for ſhortneſs of ſpeech, I ſhall not ſcruple to make uſe of the word *qualities*, ſince it is already ſo generally received, yet I would be underſtood to mean them in a ſenſe ſuitable to the doctrine above delivered. As if I ſhould ſay, that roughneſs is apt to grate and offend the ſkin, I ſhould mean, that a file or other body, by having upon its ſurface a multitude of little hard and exſtant parts, and of an angular or ſharp figure, is qualified to work the mentioned effect: and ſo if I ſhould ſay, that heat melts metals, I ſhould mean, that this fuſion is effected by fire,

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fire, or ſome other body, which, by the various and vehement motion of its inſenſible parts, does to us appear hot. And hence, (by the way,) I preſume you will eaſily gueſs at what I think of the controverſy ſo hotly diſputed of late betwixt two parties of learned men, whereof the one would have all accidents to work only in virtue of the matter they reſide in, and the other would have the matter to act only in virtue of its accidents: for conſidering, that on the one ſide, the qualities we here ſpeak of, do ſo depend upon matter, that they cannot ſo much as have a being but in and by it; and on the other ſide, if all matter were but quite devoid of motion, (to name now no other accidents,) I do not readily conceive, how it could operate at all; I think it is ſafeſt to conclude, that neither matter, nor qualities apart, but both of them conjointly do perform what we ſee done by bodies to one another, according to the doctrine of qualities juſt now delivered.

Of the Nature of a FORM.

VII. WE may now advance ſomewhat further, and conſider, that men having taken notice, that certain conſpicuous accidents were to be found aſſociated in ſome bodies, and other conventions of accidents in other bodies, they did for conveniency, and for the more expeditious expreſſion of their conceptions, agree to diſtinguiſh them into ſeveral ſorts, which they call genders or ſpecies, according as they referred them either upwards to a more comprehenſive ſort of bodies, or downward to a narrower ſpecies, or to individuals; as, obſerving many bodies to agree in being fuſible, malleable, heavy, and the like, they gave to that ſort of body the name of *metal*, which is a genus in reference to gold, ſilver, lead, and but a ſpecies in reference to that ſort of mixed bodies they call *foſſilia*: this ſuperiour genus comprehending both metals, ſtones, and divers other concretions, though itſelf be but a ſpecies in reſpect of mixed bodies. Now when any body is referred to any particular ſpecies (as of a metal, a ſtone, or the like) becauſe men have for their convenience agreed to ſignify all the eſſentials requiſite to conſtitute ſuch a body by one name, moſt of the writers of phyſicks have been apt to think, that beſides the common matter of all bodies, there is but one thing, that diſcriminates it from other kinds, and makes it what it is, and this, for brevity's ſake, they call a form: which becauſe all the qualities and other accidents of the body muſt depend on it, they alſo imagine to be a very ſubſtance, and indeed a kind of ſoul, which, united to the groſs matter, compoſes with it a natural body, and acts in it by the ſeveral qualities to be found therein, which men are wont to aſcribe to the creature ſo compoſed. But as to this affair I obſerve, that if (for inſtance) you aſk a man what gold is, if he cannot ſhew you a piece of gold, and tell you, this is gold, he will deſcribe it to you as a body, that is extremely ponderous, very malleable and ductile, fuſible and yet fixed in the fire, and of a yellowiſh colour; and if you offer to put off to him a piece of braſs for a piece of gold, he will preſently refuſe it, and (if he underſtand metals) tell you, that though your braſs be coloured like it, it is not ſo heavy, nor ſo malleable, neither will it like gold reſiſt the utmoſt brunt of the fire, or reſiſt aqua fortis. And if you aſk men, what they mean by a ruby, or nitre, or a pearl, they will ſtill make you ſuch anſwers, that you may clearly perceive, that whatever men talk in theory of ſubſtantial forms, yet that, upon whoſe account they really diſtinguiſh any one body from others, and refer it to this or that ſpecies of bodies, is nothing but an aggregate or convention of ſuch accidents, as moſt men do by a kind of agreement (for the thing is more arbitrary than we are aware of) think neceſſary or ſufficient to make a portion of the univerſal matter belong to this or that determinate genus or ſpecies of natural bodies. And therefore not only the generality of chymiſts, but divers philoſophers, and, what is more, ſome ſchoolmen themſelves, maintain it to be poſſible to tranſmute the ignobler metals into gold; which argues, that if a man could bring any parcel of matter to be yellow, and malleable and ponderous, and fixed in the fire, and upon the teſt, and indiſſoluble in aqua fortis, and in ſome to have a concurrence of all thoſe accidents, by which men try true gold from falſe, they would take it for true gold without ſcruple. And in this caſe the generality of mankind would leave the ſchool-doctors to diſpute, whether being a factitious body, (as made by the chymiſt's art) it have the ſubſtantial form of gold, and would upon the account of the convention of the freſhly mentioned accidents, let it paſs current amongſt them, notwithſtanding moſt mens greater care not to be deceived in a matter of this nature than in any other. And indeed ſince to every determinate ſpecies of bodies there doth belong more than one quality, and for the moſt part a concurrence of many is ſo eſſential to that ſort of bodies, that the want of any one of them is ſufficient to exclude it from belonging to that ſpecies; there needs no more to diſcriminate ſufficiently any one kind of bodies from all the bodies in the world, that are not of that kind; as the chymiſts *luna fixa*, which they tell us wants not the weight, the malleableneſs, nor the fixedneſs, nor any other property of gold, except the yellowneſs, (which makes them call it white gold) would by reaſon of that want of colour be eaſily known from true gold. And you will not wonder at this, if you conſider, that though ſpheres and parallelopipedons differ but in ſhape, yet this difference alone is the ground of ſo many others, that *Euclid*, and other geometricians have demonſtrated I know not how many properties of the one, which do no way belong to the other; and * *Ariſtotle* himſelf ſomewhere tells us, that a ſphere is compoſed of braſs and roundneſs. And I ſuppoſe it would be thought a man's own fault, if he could not diſtinguiſh a needle from a file, or a key from a pair of ſciſſors,

* Ariſt. Metaph. lib. 7. cap. 8.

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ſciſſors, though theſe being all made of iron, and differing but in bigneſs and ſhape, are leſs remarkably diverſe than natural bodies, the moſt part of which differ from each other in far more accidents than two. Nor need we think, that qualities being but accidents, they cannot be eſſential to a natural body; for accident, as I formerly noted, is ſometimes oppoſed to ſubſtance, and ſometimes to eſſence. And though an accident cannot be but accidental to matter, as it is a ſubſtantial thing, yet it may be eſſential to this or that particular body: as in *Ariſtotle*'s newly mentioned example, though roundneſs is but accidental to braſs, yet it is eſſential to a brazen ſphere; becauſe, though the braſs were devoid of roundneſs, (as if it were cubical, or of any other figure,) it would ſtill be a corporeal ſubſtance, yet without that roundneſs it could not be a ſphere. Wherefore ſince an aggregate or convention of qualities is enough to make the portion of matter it is found in what it is, and denominate it of this or that determinate ſort of bodies; and ſince thoſe qualities, as we have ſeen already, do themſelves proceed from thoſe more primary and catholick affections of matter, bulk, ſhape, motion or reſt, and the texture thence reſulting, why may we not ſay, that the form of a body being made up of thoſe qualities united in one ſubject, doth likewiſe conſiſt in ſuch a convention of thoſe newly named mechanical affections of matter, as is neceſſary to conſtitute a body of that determinate kind. And ſo, though I ſhall for brevity's ſake retain the word *form*, yet I would be underſtood to mean by it, not a real ſubſtance diſtinct from matter, but only the matter itſelf of a natutal body, conſidered with its peculiar manner of exiſtence; which I think may not inconveniently be called either its ſpecifical or its denominating ſtate, or its eſſential modification, or, if you would have me expreſs it in one word, its ſtamp. For ſuch a convention of accidents is ſufficient to perform the offices, that are neceſſarily required in what men call a form, ſince it makes the body ſuch as it is, making it appertain to this or that determinate ſpecies of bodies, and diſcriminating it from all other ſpecies of bodies whatſoever: As for inſtance, ponderouſneſs, ductility, fixedneſs, yellowneſs, and ſome other qualities concurring in a portion of matter, do with it conſtitute gold, and making it belong to that ſpecies we call metals, and to that ſort of metals we call gold, do both denominate and diſcriminate it from ſtones, ſalts, marchaſites, and all other ſorts of bodies, that are not metals, and from ſilver, braſs, copper, and all metals except gold. And whereas it is ſaid by ſome, that the form alſo of a body ought to be the principle of its operation, we ſhall hereafter conſider in what ſenſe that is to be admitted or rejected; in the mean time it may ſuffice us, that even in the vulgar philoſophy it is acknowledged, that natural things for the moſt part operate by their qualities, as ſnow dazles the eyes by its whiteneſs, and water ſcattered into drops of rain falls from the clouds upon the account of its gravity. To which I ſhall add, that how great the power may be, which a body may exerciſe by virtue of a ſingle quality, may appear by the various and oftentimes prodigious effects, which fire produces by its heat, when thereby it melts metals, calcines ſtones, deſtroys whole woods and cities, *&c.* And if ſeveral active qualities convene in one body, (as that which in our hypotheſis is meant by form, uſually compriſes ſeveral of them,) what great things may be thereby performed, may be ſomewhat gueſſed at by the ſtrange things we ſee done by ſome engines, which, being as engines, undoubtedly devoid of ſubſtantial forms, muſt do thoſe ſtrange things they are admired for, by virtue of thoſe accidents, the ſhape, ſize, motion, and contrivance of their parts. Not to mention, that in our hypotheſis, beſides thoſe operations, that proceed from the eſſential modification of the matter, as the body (compoſed of matter and neceſſary accidents) is conſidered *per modum unius*, as one intire corporeal agent, it may in divers caſes have other operations, upon the account of thoſe particular corpuſcles, which though they concur to compoſe it, and are, in reference to the whole, conſidered but as its parts, may yet retain their own particular nature, and divers of the peculiar qualities: as in a watch, beſides thoſe things, which the watch performs as ſuch, the ſeveral parts, whereof it conſiſts as the ſpring, the wheels, the ſtring, the pins, *&c.* may have each of them its peculiar bulk, ſhape, and other attributes, upon the account of one or more of which the wheel or ſpring, *&c.* may do other things than what it doth, as merely a conſtituent part of the watch. And ſo in the milk of a nurſe, that hath ſome hours before taken a potion, though the corpuſcles of the purging medicine appear not to ſenſe diſtinct from the other parts of the milk, which in far greater numbers concur with them to conſtitute that white liquor; yet theſe purgative particles, that ſeem to be but part of the matter whereof the milk conſiſts, do yet ſo retain their own nature and qualities, that being ſucked in with the reſt by the infant, they quickly diſcriminate and diſcover themſelves by purging him. But of this ſubject more hereafter.

Of Generation, Corruption, and Alteration.

VIII. IT now remains, that we declare, what, according to the tenor of our hypotheſis, is to be meant by generation, corruption, and alteration; (three names, that have very much puzzled and divided philoſophers.) In order hereunto we may conſider,

1. THAT there are in the world great ſtore of particles of matter, each of which is too ſmall to be, whilſt ſingle, ſenſible; and being intire or undivided, muſt needs both have its determinate ſhape, and be very ſolid. Inſomuch, that though it be mentally, and by divine omnipotence diviſible, yet by reaſon of its ſmallneſs and ſolidity, nature doth ſcarce ever actually divide it; and theſe may in this ſenſe be called *minima* or *prima naturalia*.

2. THAT

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2. THAT there are alſo multitudes of corpuſcles, which are made up of the coalition of ſeveral of the former *minima naturalia*; and whoſe bulk is ſo ſmall, and their adheſion ſo cloſe and ſtrict, that each of theſe little primitive concretions or cluſters (if I may ſo call them) of particles is ſingly below the diſcernment of ſenſe, and though not abſolutely indiviſible by nature into the *prima naturalia*, that compoſed it, or perhaps into other little fragments, yet, for the reaſons freſhly intimated, they very rarely happen to be actually diſſolved or broken, but remain intire in great variety of ſenſible bodies, and under various forms or diſguiſes. As, not to to repeat what we lately mentioned, of the undeſtroyed purging corpuſcles of milk; we ſee, that even groſſer and more compounded corpuſcles may have ſuch a permanent texture: for quickſilver, for inſtance, may be turned into a red powder for a fuſible and malleable body, or a fugitive ſmoke, and diſguiſed I know not how many other ways, and yet remain true and recoverable mercury. And theſe are, as it were, the ſeeds or immediate principles of many ſorts of natural bodies, as earth, water, ſalt, *&c.* and thoſe ſingly inſenſible, become capable, when united, to affect the ſenſe: as I have tried, that if good camphire be kept a while in pure ſpirit of wine, it will thereby be reduced into ſuch little parts, as totally to diſappear in the liquor, without making it look leſs clear than fair water; and yet, if into this mixture you pour a competent quantity of water, in a moment the ſcattered corpuſcles of the camphire will, by reuniting themſelves, become white, and conſequently viſible, as before their diſperſion.

3. THAT as well each of the *minima naturalia*, as each of the primary cluſters aabove mentioned, having its own determinate bulk and ſhape, when theſe come to adhere to one another, it muſt always happen, that the ſize, and often, that the figure of the corpuſcle compoſed by their juxta-poſition and coheſion, will be changed: and not ſeldom too, the motion either of the one, or the other, or both, will receive a new tendency, or be altered as to its velocity or otherwiſe: and the like will happen, when the corpuſcles, that compoſe a cluſter of particles, are disjoined, or any thing of the little maſs is broken off. And whether any thing of matter be added to a corpuſcle, or taken from it in either caſe, (as we juſt now intimated,) the ſize of it muſt neceſſarily be altered, and for the moſt part the figure will be ſo too, whereby it will both acquire a congruity to the pores of ſome bodies, (and perhaps ſome of our ſenſories,) and become incongruous to thoſe of others; and conſequently be qualified, as I ſhall more fully ſhew you hereafter, to operate on divers occaſions, much otherwiſe than it was fitted to do before.

4. THAT when many of theſe inſenſible corpuſcles come to be aſſociated into one viſible body, if many or moſt of them be put into motion, from what cauſe ſoever the motion proceeds, that itſelf may produce great changes, and new qualities in the body they compoſe; for not only motion may perform much, even when it makes not any viſible alteration in it, as air put into ſwift motion, (as when it is blown out of bellows) acquires a new name, and is called *wind*, and to the touch appears far colder than the ſame air not ſo formed into a ſtream; and iron, by being briſkly rubbed againſt wood, or other iron, hath its ſmall parts ſo agitated, as to appear hot to our ſenſe: but this motion oftentimes makes viſible alterations in the texture of the body into which it is received; for always the moved parts ſtrive to communicate their motion, or ſomewhat of the degree of it, to ſome parts, that were before either at reſt, or otherwiſe moved, and oftentimes the ſame moved parts do thereby either disjoin or break ſome of the corpuſcles they hit againſt, and thereby change their bulk or ſhape, or both, and either drive ſome of them quite out of the body, and perhaps lodge themſelves in their places, or elſe aſſociate them anew with others. Whence it uſually follows, that the texture is for a while at leaſt, and unleſs it be very ſtable and permanent, for good and all, very much altered, and eſpecially in that the pores or little intervals intercepted betwixt the component particles will be changed as to bigneſs, or figure, or both, and ſo will ceaſe to be commenſurate to the corpuſcles that were fit for them before, and become commenſurate to ſuch corpuſcles of other ſizes and ſhapes, as till then were incongruous to them. Thus we ſee, that water, by loſing the wonted agitation of its parts, may acquire the firmneſs and brittleneſs we find in ice, and loſe much of the tranſparency it had whilſt it was a liquor. Thus alſo, by very hard rubbing two pieces of reſinous wood againſt one another, we may make them throw out divers of their looſer parts into ſteams and viſible ſmoke; and may, if the attrition be duly continued, make that commotion of the parts ſo change the texture of the whole, as afterwards to turn the ſuperficial parts into a kind of coal. And thus milk, eſpecially in hot weather, will by the inteſtine, though languid motions of its parts, be in a ſhort time turned into a thinner ſort of liquor than milk, and into cream, and this (laſt named) will, by being barely agitated in a churn, be turned in a ſhorter time into that unctuous and conſiſtent body we call butter, and into thin, fluid, and ſour butter-milk. And thus (to diſpatch) by the bruiſing of fruit, the texture is commonly ſo changed, that, as we ſee particularly in apples, the bruiſed part ſoon comes to be of another nature than the ſound part, the one differing from the other both in colour, taſte, ſmell, and conſiſtence. So that (as we have already inculcated) local motion hath, of all other affections of matter, the greateſt intereſt in the altering and modifying of it; ſince it is not only the grand agent or efficient among ſecond cauſes, but is alſo oftentimes one of the principal things that conſtitutes the form of bodies. As when two ſticks are ſet on fire by long and vehement attrition, local motion

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is not only that, which kindles the wood, and ſo as an efficient produces the fire, but is that, which principally concurs to give the produced ſtream of ſhining matter, the name and nature of flame: and ſo it concurs alſo to conſtitute all fluid bodies.

5. AND that ſince we have formerly ſeen, that it is from the ſize, ſhape, and motion of the ſmall parts of matter, and the texture that reſults from the manner of their being diſpoſed in any one body, that the colour, odour, taſte, and other qualities of that body are to be derived, it will be eaſy for us to recollect, that ſuch changes cannot happen in a portion of matter, without ſo much varying the nature of it, that we need not deride the antient atomiſts, for attempting to deduce the generation and corruption of bodies from the famed σύγκρισις καὶ διάκρισις, the *convention* and *diſſolution*, and the alterations of them, from the tranſpoſition of their (ſuppoſed) atoms. For though indeed nature is wont in the changes ſhe makes among things corporeal, to imploy all the three ways, as well in alterations as generations and corruptions; yet if they only meant, as probably enough they did, that of the three ways propoſed, the firſt was wont to be the principal in the generation of bodies, the ſecond in the corruption, and the third in their alterations; I ſhall not much oppoſe this doctrine: though I take the local motion or tranſpoſition of parts in the ſame portion of matter to bear a great ſtroke as well in reference to generation and corruption, as to alteration: as we ſee when milk or fleſh, or fruit, without any remarkable addition or loſs of parts, turns into maggots, or other inſects; and as we may more conſpicuouſly obſerve in the precipitation of mercury, without addition, in the vitrification of metals, and other chymical experiments to be hereafter mentioned.

Theſe things premiſed, it will not now be difficult to compriſe in few words ſuch a doctrine, touching the generation, corruption, and alteration of bodies, as is ſuitable to our hypotheſis and the former diſcourſe. For if in a parcel of matter there happen to be produced (it imports not much how) a concurrence of all thoſe accidents, (whether thoſe only or more) that men by tacit agreement have thought neceſſary and ſufficient to conſtitute any one determinate ſpecies of things corporeal, then we ſay, that a body belonging to that ſpecies, as ſuppoſe a ſtone, or a metal, is generated or produced *de novo*. Not that there is really any thing of ſubſtantial produced, but that thoſe parts of matter, that did indeed before præexiſt, but were either ſcattered and ſhared among other bodies, or at leaſt otherwiſe diſpoſed of, are now brought together, and diſpoſed of after the manner requiſite, to entitle the body, that reſults from them, to a new denomination, and make it appertain to ſuch a determinate ſpecies of natural bodies, ſo that no new ſubſtance is in generation produced, but only that, which was præexiſtent, obtains a new modification, or manner of exiſtence. Thus when the ſpring, and wheels, and ſtring, and balance, and index, &c. neceſſary to a watch, which lay before ſcattered, ſome in one part, ſome in another of the artificer's ſhop, are firſt ſet together in the order requiſite to make ſuch an engine, to ſhew how the time paſſes, a watch is ſaid to be made: not that any of the mentioned material parts is produced *de novo*, but that till then the divided matter was not ſo contrived and put together, as was requiſite to conſtitute ſuch a thing as we call a watch. And ſo when ſand and aſhes are well melted together, and ſuffered to cool, there is generated by the colliquation that ſort of concretion we call glaſs, though it be evident, that its ingredients were both præexiſtent, and do but by their aſſociation obtain a new manner of exiſting together. And ſo when, by the churning of cream, butter and butter-milk are generated, we find not any thing ſubſtantial produced *de novo* in either of them, but only that the ſerum, and the fat corpuſcles, being put into local motion, do by their frequent occurſions extricate themſelves from each other, and aſſociate themſelves in the new manner, requiſite to conſtitute the bodies, whoſe names are given them.

AND as a body is ſaid to be generated, when it firſt appears clothed with all thoſe qualities, upon whoſe account men have been pleaſed to call ſome bodies ſtones; others, metals; others, ſalts, &c. ſo when a body comes to loſe all or any of thoſe accidents, that are eſſential, and neceſſary to the conſtituting of ſuch a body, it is then ſaid to be corrupted or deſtroyed, and is no more a body of that kind, but loſes its title to its former denomination. Not that any thing corporeal or ſubſtantial periſhes in this change, but only that the eſſential modification of the matter is deſtroyed: and though the body be ſtill a body, (no natural agent being able to annihilate matter,) yet it is no longer ſuch a body, as it was before, but periſheth in the capacity of a body of that kind. Thus, if a ſtone, falling upon a watch, break it to pieces, as, when the watch was made, there was no new ſubſtance produced, all the material parts (as the ſteel, braſs, ſtring, &c.) being præexiſtent ſomewhere or other, (as in iron and copper mines in the bellies of thoſe animals, of whoſe guts men uſe to make ſtrings;) ſo not the leaſt part of the ſubſtance of the watch is loſt, but only diſplaced and ſcattered; and yet that portion of matter ceaſes to be a watch, as it was before. And ſo (to reſume our late example) when cream is by churning turned into butter, and a ſerous liquor, the parts of the milk remain aſſociated into thoſe new bodies, but the white liquor periſheth in the capacity of milk. And ſo when ice comes to be thawed in exactly-cloſed veſſels, though the corruption be produced only (for aught appears) by introducing a new motion and diſpoſition into the parts of the frozen water, yet it thereupon ceaſes to be ice, however it be as much water, and conſequently as much a body, as before it

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was frozen or thawed. Theſe, and the like examples, may teach us rightly to underſtand that common axiom of naturaliſts, *Corruptio unius eſt generatio alterius*; *& è contrà*: for ſince it is acknowledged on all hands, that matter cannot be annihilated, and ſince it appears by what we have ſaid above, that there are ſome properties, namely, ſize, ſhape, motion, (or, in its abſence, reſt,) that are inſeparable from the actual parts of matter; and ſince alſo the coalition of any competent number of theſe parts is ſufficient to conſtitute a natural body, endowed with divers ſenſible qualities, it can ſcarce be otherwiſe, but that the ſame agents, that ſhatter the frame, or deſtroy the texture of one body, will by ſhuffling them together, and diſpoſing them after a new manner, bring them to conſtitute ſome new ſort of bodies: as the ſame thing, that by burning deſtroys wood, turns it into flame, ſoot, and aſhes. Only I doubt, whether the axiom do generally hold true, if it be meant, that every corruption muſt end in the generation of a body belonging to ſome particular ſpecies of things, unleſs we take powders and fluid bodies indefinitely for ſpecies of natural bodies; ſince it is plain, there are multitudes of vegetables, and other concretions, which, when they rot, do not, as ſome others do, turn into worms, but either into ſome ſlimy or watery ſubſtance, or elſe (which is the moſt uſual) they crumble into a kind of duſt or powder, which, though looked upon as being the earth, into which rotten bodies are at length reſolved, is very far from being of an elementary nature, but as yet a compounded body, retaining ſome, if not many qualities, which often makes the duſt of one ſort of plant or animal differ much from that of another. And this will ſupply me with this argument *ad hominem*, *viz.* That ſince in thoſe violent corruptions of bodies, that are made by outward agents, ſhattering them into pieces, if the axiom hold true, the new bodies emergent upon the diſſolution of the former, muſt be really natural bodies, as (indeed divers of the moderns hold them to be,) and generated according to the courſe of nature; as when wood is deſtroyed by fire, and turned partly into flame, partly into ſoot, partly into coals, and partly into aſhes, I hope we may be allowed to conclude, that thoſe chymical productions, which ſo many would have to be but factitious bodies, are natural ones, and regularly generated. For it being the ſame agent, the fire, that operates upon bodies, whether they be expoſed to it in cloſe glaſſes, or in chimneys, I ſee no ſufficient reaſon, why the chymical oils, and volatile ſalts, and other things, which Spagyrites obtain from mixed bodies, ſhould not be accounted natural bodies, as well as the ſoot and aſhes, and charcoal, that by the ſame fire are obtained from kindled wood.

BUT before we paſs away from the mention of the corruption of bodies, I muſt take ſome notice of what is called their putrefaction. This is but a peculiar kind of corruption, wrought ſlowly (whereby it may be diſtinguiſhed from deſtruction by fire, and other nimble agents) in bodies: it happens to them for the moſt part by means of the air, or ſome other ambient fluid, which by penetrating into the pores of the body, and by its agitation in them doth uſually call out ſome of the more agile and leſs intangled parts of the body, and doth almoſt ever looſen and diſlocate the parts in general, and thereby ſo change the texture, and perhaps too the figure of the corpuſcles, that compoſe it, that the body, thus changed, acquires qualities unſuitable to its former nature, and for the moſt part offenſive to our ſenſes, eſpecially of ſmelling and taſting: which laſt clauſe I therefore add, not only becauſe the vulgar look not upon the change of an egg into a chick as a corruption, but as a perfection of the egg; but becauſe alſo I think it not improbable, that if by ſuch ſlow changes of bodies, as make them loſe their former nature, and might otherwiſe paſs for putrefaction, many bodies ſhould acquire better ſcents or taſtes than before; or if nature, cuſtom, or any other cauſe ſhould much alter the texture of our organs of taſting and ſmelling, it would not perhaps be ſo well agreed on what ſhould be called putrefaction, as that imports an impairing alteration, but men would find ſome favourabler notion for ſuch changes. For I obſerve, that medlars, though they acquire in length of time ſuch a colour and ſoftneſs as rotten apples, and other putrified fruits do; yet, becauſe their taſte is not then harſh as before, we call that ripeneſs in them, which otherwiſe we ſhould call rottenneſs. And though upon the death of a four-footed beaſt, we generally call that change, which happens to the fleſh or blood, putrefaction, yet we paſs a more favourable judgment upon that, which happens to the fleſh, and other ſofter parts of that animal, (whether it be a kind of large rabbits, or very ſmall and hornleſs deer,) of which in *China*, and in the *Levant*, they make muſk; becauſe by the change, that enſues the animal's death, the fleſh acquires not an odious, but a grateful ſmell. And we ſee, that ſome men, whoſe appetites are gratified by rotten cheeſe, think it then not to have degenerated, but to have attained its beſt ſtate, when having loſt its former colour, ſmell, and taſte, and, which is more, being in great part turned into thoſe inſects called mites, it is both in a philoſophical ſenſe corrupted, and in the eſtimate of the generality of men grown putrid. But becauſe it very ſeldom happens, that a body by generation acquires no other qualities than juſt thoſe, that are abſolutely neceſſary to make it belong to the ſpecies, that denominates it, therefore in moſt bodies there are divers other qualities, that may be there, or may be miſſing, without eſſentially changing the ſubject: as water may be clear or muddy, odorous or ſtinking, and ſtill remain water; and butter may be white or yellow, ſweet or rancid, conſiſtent or melted, and ſtill be called butter. Now therefore whenſoever

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a parcel of matter does acquire or loſe a quality, that is not eſſential to it, that acquiſition or loſs is diſtinctly called alteration, (or by ſome, mutation:) the acquiſt only of the qualities, that are abſolutely neceſſary to conſtitute its eſſential and ſpecifical difference, or the loſs of any of thoſe qualities, being ſuch a change, as muſt not be called meer alteration, but have the particular name of generation or corruption; both which, according to this doctrine, appear to be but ſeveral kinds of alteration, taken in a large ſenſe, though they are diſtinguiſhed from it in a more ſtrict and limited acceptation of that term.

AND here we have a fair occaſion to take notice of the fruitfulneſs and extent of our mechanical hypotheſis: for ſince, according to our doctrine, the world we live in is not a moveleſs or indigeſted maſs of matter, but an Αυτόματον, or *ſelf-moving engine*, wherein the greateſt part of the common matter of all bodies is always (though not ſtill the ſame parts of it) in motion, and wherein bodies are ſo cloſe ſet by one another, that (unleſs in ſome very few and extraordinary, and as it were preternatural caſes) they have either no vacuities betwixt them, or only here and there interpoſed and very ſmall ones: And ſince, according to us, the various manner of the coalition of ſeveral corpuſcles into one viſible body is enough to give them a peculiar texture, and thereby fit them to exhibit divers ſenſible qualities, and to become a body, ſometimes of one denomination, and ſometimes of another; it will very naturally follow, that from the various occurſions of thoſe innumerable ſwarms of little bodies, that are moved to and fro in the world, there will be many fitted to ſtick to one another, and ſo compoſe concretions; and many (though not in the ſelf-ſame place) disjoined from one another, and agitated apart; and multitudes alſo, that will be driven to aſſociate themſelves, now with one body, and preſently with another. And if we alſo conſider on the one ſide, that the ſizes of the ſmall particles of matter may be very various, their figures almoſt innumerable; and that if a parcel of matter do but happen to ſtick to one body, it may chance to give it a new quality, and if it adhere to another, or hit againſt ſome of its parts, it may conſtitute a body of another kind; or if a parcel of matter be knocked off from another, it may barely by that leave it, and become itſelf of another nature than before: If, I ſay, we conſider theſe things on the one ſide, and on the other ſide, that (to uſe *Lucretius* his compariſon) all that innumerable multitude of words, that are contained in all the languages of the world, are made of the various combinations of ſome of the twenty four letters of the alphabet; it will not be hard to conceive, that there may be an incomprehenſible variety of aſſociations and textures of the minute parts of bodies, and conſequently a vaſt multitude of portions of matter endowed with ſtore enough of differing qualities, to deſerve diſtinct appellations; though for want of heedfulneſs and fit words, men have not yet taken ſo much notice of their leſs obvious varieties, as to ſort them as they deſerve, and give them diſtinct and proper names. So that though I would not ſay, that any thing can immediately be made of every thing, as a gold ring of a wedge of gold, or oil, or fire of water; yet ſince bodies, having but one common matter, can be differenced but by accidents, which ſeem all of them to be the effects and conſequents of local motion, I ſee not, why it ſhould be abſurd to think, that (at leaſt among inanimate bodies) by the intervention of ſome very ſmall addition or ſubſtraction of matter, (which yet in moſt caſes will ſcarce be needed,) and of an orderly ſeries of alterations, diſpoſing by degrees the matter to be tranſmuted, almoſt of any thing, may at length be made any thing: as, though out of a wedge of gold one cannot immediately make a ring, yet by either wire-drawing that wedge by degrees, or by melting it, and caſting a little of it into a mould, that thing may be eaſily effected. And ſo though water cannot immediately be tranſmuted into oil, and much leſs into fire; yet if you nouriſh certain plants with water alone, (as I have done,) till they have aſſimilated a great quantity of water into their own nature, you may, by committing this tranſmuted water (which you may diſtinguiſh and ſeparate from that part of the vegetable you firſt put in) to diſtillation in convenient glaſſes, obtain, beſides other things, a true oil, and a black combuſtible coal, (and conſequently fire;) both of which may be ſo copious, as to leave no juſt cauſe to ſuſpect, that they could be any thing near afforded by any little ſpirituous parts, which may be preſumed to have been communicated by that part of the vegetable, that is firſt put into the water, to that far greater part of it, which was committed to diſtillation.

BUT, *Pyrophilus*, I perceive the difficulty and fruitfulneſs of my ſubject have made me ſo much more prolix than I intended, that it will not now be amiſs to contract the ſummary of our hypotheſis, and give you the main points of it with little or no illuſtration, and without particular proofs, in a few words. We teach then (but without peremptorily aſſerting it,)

1. THAT the matter of all natural bodies is the ſame; namely, a ſubſtance extended and impenetrable.

2. THAT all bodies thus agreeing in the ſame common matter, their diſtinction is to be taken from thoſe accidents, that do diverſify it.

3. THAT motion, not belonging to the eſſence of matter, (which retains its whole nature when it is at reſt,) and not being originally producible by other accidents, as they are from it, may be looked upon as the firſt and chief mood or affection of matter.

4. THAT motion, variouſly determined, doth naturally divide the matter it belongs to into actual fragments of parts; and this diviſion,

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viſion, obvious experience (and more eminently, chymical operations) manifeſt to have been made into parts exceedingly minute, and very often too minute to be ſingly perceivable by our ſenſes.

5. WHENCE it muſt neceſſarily follow, that each of theſe minute parts or *minima naturalia*, (as well as every particular body, made up by the coalition of any number of them,) muſt have its determinate bigneſs or ſize, and its own ſhape. And theſe three; namely, bulk, figure, and either motion or reſt, (there being no mean between theſe two) are the three primary and moſt catholick moods or affections of the inſenſible parts of matter, conſidered each of them apart.

6. THAT when divers of them are conſidered together, there will neceſſarily follow here below both a certain poſition or poſture in reference to the horizon (as erected, inclining, or level) of each of them, and a certain order or placing before or behind, or beſides one another; as when in a company of ſoldiers one ſtands upright, the other ſtoops, the other lies along upon the ground, they have various poſtures; and their being placed beſides one another in ranks, and behind one another in files are varieties of their order: and when many of theſe ſmall parts are brought to convene into one body from their primary affections, and their diſpoſition or contrivance as to poſture and order, there reſults that, which by one comprehenſive name we call the texture of that body. And indeed theſe ſeveral kinds of location, (to borrow a ſcholaſtical term,) attributed in this ſixth number to the minute particles of bodies, are ſo near of kin, that they ſeem all of them referable to (that one event of their convening) ſituation or poſition. And theſe are the affections, that belong to a body, as it is conſidered in itſelf, without relation to ſenſitive beings, or to other natural bodies.

7. THAT yet there being men in the world, whoſe organs of ſenſe are contrived in ſuch differing ways, that one ſenſory is fitted to receive impreſſions from ſome, and another from other ſorts of external objects or bodies without them, (whether theſe act as intire bodies, or by emiſſion of their corpuſcles, or by propagating ſome motion to the ſenſory,) the perceptions of theſe impreſſions are by men called by ſeveral names, as heat, colour, ſound, odour; and are commonly imagined to proceed from certain diſtinct and peculiar qualities in the external object, which have ſome reſemblance to the ideas, their action upon the ſenſes excites in the mind; though indeed all theſe ſenſible qualities, and the reſt, that are to be met with in the bodies without us, are but the effects or conſequents of the above mentioned primary affections of matter, whoſe operations are diverſified, according to the nature of the ſenſories, or other bodies they work upon.

8. THAT when a portion of matter, either by the acceſſion or receſs of corpuſcles, or by the tranſpoſition of thoſe it conſiſted of before, or by any two or all of theſe ways, happens to obtain a concurrence of all thoſe qualities, which men commonly agree to be neceſſary and ſufficient to denominate the body, which hath them, either a metal or a ſtone, or the like, and to rank it in any peculiar and determinate ſpecies of bodies, then a body of that denomination is ſaid to be generated.

9. THIS convention of eſſential accidents being taken (not any of them apart, but all) together for the ſpecifical difference that conſtitutes the body, and diſcriminates it from all other ſorts of bodies, is by one name, becauſe conſidered as one collective thing, called its form, (as beauty, which is made up of ſymmetry of parts, and agreeableneſs of colours,) which is conſequently but a certain character, (as I ſometimes call it,) or a peculiar ſtate of matter, or, if I may ſo name it, an eſſential modification: a modification, becauſe it is indeed but a determinate manner of exiſtence of the matter, and yet an eſſential modification, becauſe that though the concurrent qualities be but accidental to matter, (which, with others inſtead of them, would be matter ſtill,) yet they are eſſentially neceſſary to the particular body, which without thoſe accidents would not be a body of that denomination, as a metal or a ſtone, but of ſome other.

10. Now a body being capable of many other qualities beſides thoſe, whoſe convention is neceſſary to make up its form; the acquiſition or loſs of any ſuch quality is by naturaliſts, in the more ſtrict ſenſe of that term, named alteration: as when oil comes to be frozen, or to change colour, or to grow rancid; but if all or any of the qualities, that are reputed eſſential to ſuch a body, come to be loſt or deſtroyed, that notable change is called corruption. As when oil being boiled takes fire, the oil is not ſaid to be altered in the former ſenſe, but corrupted or deſtroyed, and the emergent fire generated; and when it ſo happens, that the body is ſlowly corrupted, and thereby alſo acquires qualities offenſive to our ſenſes, eſpecially of ſmell and taſte, (as when fleſh or fruit grows rotten,) that kind of corruption is by a more particular name called putrefaction. But neither in this, nor in any other kind of corruption is there any thing ſubſtantial deſtroyed, (no ſuch thing having been produced in generation, and matter itſelf being on all hands acknowledged incoruptible,) but only that ſpecial connexion of the parts, or manner of their co-exiſtence, upon whoſe account the matter (whilſt it was in its former ſtate) was, and was called a ſtone, or a metal, or did belong to any other determinate ſpecies of bodies.

A N

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AN

EXAMEN

OF THE

ORIGIN and DOCTRINE

OF

SUBSTANTIAL FORMS,

As it is wont to be taught by the PERIPATETICKS.

THE origin of forms, *Pyrophilus*, as it is thought the nobleſt, ſo, if I miſtake not, it hath been found one of the moſt * perplexed inquiries, that belong to natural philoſophy: and, I confeſs, it is one of the things, that has invited me to, look about for ſome more ſatisfactory account than the ſchools uſually give of this matter, that I have obſerved, that the wiſeſt, that have buſied themſelves in explicating forms according to the Peripatetick notions of them, have either knowingly confeſſed themſelves unable to explain them, or unwittingly proved themſelves to be ſo, by giving but unſatisfactory explications of them.

IT will not, I preſume, be expected, that I, who now write but notes, ſhould enumerate, much leſs examine all the various opinions touching the origin and nature of forms; it being enough for our purpoſe, if having already intimated in our hypotheſis, what, according to that, may be thought of this ſubject; we now briefly conſider the general opinion of our modern Ariſtotelians and the ſchools concerning it: I ſay, the modern Ariſtotelians, becauſe divers of the ancient, eſpecially Greek commentators of *Ariſtotle*, ſeem to have underſtood their maſters doctrine of forms much otherwiſe, and leſs incongruouſly, than his Latin followers, the ſchoolmen and others, have ſince done. Nor do I expreſly mention *Ariſtotle* himſelf among the champions of ſubſtantial forms, becauſe though he ſeem in a place or two expreſly enough to reckon forms among ſubſtances, yet elſewhere the examples he employs to ſet forth the forms of natural things by, being taken from the figures of artificial things, (as of a ſtatue, *&c.*) which are confeſſedly but accidents, and making very little uſe, if any, of ſubſtantial forms to explain the phænomena of nature, he ſeems to me upon the whole matter either to have been irreſolved, whether there were any ſuch ſubſtances or no, or to ſpeak ambiguouſly and obſcurely enough of them, to make it queſtionable what his opinions of them were.

BUT the ſum of the controverſy betwixt us and the ſchools is this, whether or no the forms of natural things (the ſouls of men always excepted) be in generation educed, as they ſpeak, out of the power of the matter, and whether theſe forms be true ſubſtantial entities, diſtinct from the other ſubſtantial principle of natural bodies, namely matter.

THE reaſons, that move me to embrace the negative, are principally theſe three: firſt, that I ſee no neceſſity of admitting in natural things any ſuch ſubſtantial forms; matter, and the accidents of matter, being ſufficient to explicate as much of the phænomena of nature, as we either do or are like to underſtand. The next, that I ſee not what uſe this puzzling doctrine of ſubſtantial forms is of in natural philoſophy; the acute *Scaliger*, and thoſe, that have moſt buſied themſelves in the indagation of them, having freely acknowledged (as the more candid of the Peripateticks generally do,) that the true knowlege of forms is too difficult and abſtruſe to be attained by them. And how like it is, that particular phænomena will be explained by a principle, whoſe nature is confeſſedly ignored, I leave you to judge. But becauſe to theſe conſiderations I often have had, and ſhall have here and there occaſion to ſay ſomething in the body of theſe notes, I ſhall at preſent inſiſt upon the third; which is, that I cannot conceive, neither how forms can be generated, as the Peripateticks would have it, nor how the things they aſcribe to them are conſiſtent with the principles of true philoſophy, or even with what themſelves otherwiſe teach.

THE manner how forms are educed out of the power of the matter, according to that part of the doctrine of forms, wherein the ſchools

* *Formarum cognitio eſt rudis, confuſa, nec niſi per περιφάσεις; neque verum eſt, formæ ſubſtantialis ſpeciem recipi in intellectum, non enim in ſenſu uſquam fuit.* J. C. Scalig.

Formæ ſubſtantiales ſunt incognitæ nobis, quia inſenſiles: ideo per qualitates, quæ ſunt principia immediata tranſmutationis, exprimuntur. Aquinas ad 1. de generat. & corrupt.

In hac humanæ mentis caligine æquè forma ignis ac magnetis nobis ignota eſt. Sennertus

ſchools generally enough agree, is a thing ſo inexplicable, that I wonder not it hath put acute men upon ſeveral hypotheſes to make it out. And indeed the number of theſe is of late grown too great to be fit to be here recited, eſpecially ſince I find them all ſo very unſatisfactory, that I cannot but think the acute ſticklers for any of them are rather driven to embrace it by the palpable inconveniences of the ways they reject, than by any thing they find to ſatisfy them in that, which they make choice of: and for my part I confeſs, I find ſo much reaſon in what each party ſays againſt the explications of the reſt, that I think they all confute well, and none does well eſtabliſh.

BUT my preſent way of writing forbidding me to inſiſt on many arguments againſt the doctrine, wherein they moſt agree, I ſhall only urge that, which I confeſs chiefly ſticks with me; namely, that I find it not comprehenſible.

I KNOW the modern ſchoolmen fly here to their wonted refuge of an obſcure diſtinction, and tell us, that the power of matter in reference to forms is partly eductive, as the agent can make the form out of it, and partly receptive, whereby it can receive the form ſo made. But ſince thoſe, that ſay this, will not allow, that the form of a generated body was actually præexiſtent in its matter, or indeed any where elſe, it is hard to conceive, how a ſubſtance can be educed out of another ſubſtance, totally diſtinct in nature from it, without being, before ſuch eduction, actually exiſtent in it. And as for the receptive power of the matter, that but fitting it to receive or lodge a form, when brought to be united with it, how can it be intelligibly made out to contribute to the production of a new ſubſtance of a quite differing nature from that matter, though it harbours it when produced? And it is plain, that the human body hath a receptive power in reference to the human ſoul, which yet themſelves confeſs both to be a ſubſtantial form, and not to be educed out of the power of matter. Indeed if they would admit the form of a natural body to be but a more fine and ſubtile part of the matter, as ſpirit of wine is of wine, which upon its receſs remains no longer wine, but phlegm or vinegar, then the eductive power of matter might ſignify ſomething: and ſo it might, if with us they would allow the form to be but a modification of the matter; for then it would import, but that the matter may be ſo ordered or diſpoſed by fit agents, as to conſtitute a body of ſuch a ſort and denomination: and ſo (to reſume that example) the form of a ſphere may be ſaid to lurk potentially in a piece of braſs, in as much as that braſs may, by caſting, turning, or otherwiſe, be ſo figured as to become a ſphere. But this they will not admit, leſt they ſhould make forms to be but accidents, though it is, for aught I know, as little intelligible how what is educed out of any matter, without being either præexiſtent, or being any part of the matter, can be a true ſubſtance, as how that roundneſs, that makes a piece of braſs become a ſphere, can be a new ſubſtance in it. Nor can they admit the other way of educing a form out of matter, as ſpirit is out of wine, becauſe then not only matter will be corruptible againſt their grounds, but matter and form would not be two differing and ſubſtantial principles, but one and the ſame, though diverſified by firmneſs, groſſneſs, *&c.* which are but accidental differences. I know they ſpeak much of the efficacy of the agent upon the matter in the generation of natural bodies, and tell us ſtrange things of his manner of working. But not to ſpend time in examining thoſe obſcure niceties, I anſwer in ſhort, That ſince the agent, be he what he will, is but a phyſical and finite agent, and ſince what way ſoever he works, he can do nothing repugnant to the nature of things, the difficulty, that ſticks with me, will ſtill remain. For if the form produced in generation be, as they would have it, a ſubſtance, that was not before to be found any where out of that portion of matter, wherewith it conſtitutes the generated body; I ſay, that either it muſt be produced by refining or ſubtiliating ſome parts of the matter into form, or elſe it muſt be produced out of nothing, that is, created: (for I ſee no third way, how a ſubſtance can be produced *de novo.*) If they allow the firſt, then will the form be indeed a ſubſtance, but not, as they hold it is, diſtinct from matter; ſince matter, however ſubtiliated, is matter ſtill, as the the fineſt ſpirit of wine is as truly a body, as was the wine itſelf that yielded it, or as is the groſſer phlegm, from which it was extracted: beſides tha, the Peripateticks teach, that the form is not made of any thing of the matter; nor indeed is it conceivable, how a phyſical agent can turn a material into an immaterial ſubſtance, eſpecially matter being, as they themſelves confeſs, as well incorruptible as ingenerable. But if they will not allow, as indeed they do not, that the ſubſtantial form is made of any thing, that is material, they muſt give me leave to believe, that it is produced out of nothing, till they ſhew me, how a ſubſtance can be produced otherwiſe, that exiſted no where before. And at this rate every natural body of a ſpecial denomination, as gold, marble, nitre, *&c.* muſt not be produced barely by generation, but partly by generation and partly by creation. And ſince it is confeſſed on all ſides, that no natural agent can produce the leaſt atom of matter, it is ſtrange they ſhould in generation allow every phyſical agent the power of producing a form, which, according to them, is not only a ſubſtance, but a far nobler one than matter; and thereby attribute to the meaneſt creatures that power of creating ſubſtances, which the ancient naturaliſts thought too great to be aſcribed to God himſelf, and which indeed is too great to be aſcribed to any other than him. And therefore ſome ſchoolmen and philoſophers have derived forms immediately from God; but this is not only to deſert *Ariſtotle* and the Peripatetick philoſophy they would ſeem to

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maintain, but to put omnipotence upon working I know not how many thouſand miracles every hour, to perform that (I mean, the generation of bodies of new denominations) in a ſupernatural way, which ſeems the moſt familiar effect of nature in her ordinary courſe.

AND as the production of forms out of the power of matter is for theſe reaſons incomprehenſible to me; ſo thoſe things, which the Peripateticks aſcribe to their ſubſtantial forms, are ſome of them ſuch, as, I confeſs, I cannot reconcile my reaſon to: for they tell us poſitively, that theſe forms are ſubſtances, and yet at the ſame time they teach, that they depend upon matter both *in fieri* and *in eſſe*, as they ſpeak; ſo that out of the matter, that ſupports them, they cannot ſo much as exiſt, (whence they are uſually called material forms) which is to make them ſubſtances in name, and but accidents in truth. For not to aſk, how (among phyſical things) one ſubſtance can be ſaid to depend upon another *in fieri*, that is not made of any part of it, the very notion of a ſubſtance is to be a ſelf-ſubſiſting entity, or that, which needs no other created being to ſupport it, or to make it exiſt. Beſides that, there being but two ſorts of ſubſtances, material and immaterial, a ſubſtantial form muſt appertain to one of the two, and yet they aſcribe things to it, that make it very unfit to be referred to either. To all this I add, that theſe imaginary material forms do almoſt as much trouble the doctrine of corruption, as that of generation: for if a form be a true ſubſtance really diſtinct from matter, it muſt, as I lately noted, be able to exiſt of itſelf, without any other ſubſtance to ſupport it; as thoſe I reaſon with confeſs, that the ſoul of man ſurvives the body it did before death inform: whereas they will have it, that in corruption the form is quite aboliſhed, and utterly periſhes, as not being capable of exiſting, ſeparated from the matter, whereunto it was united. So that here again, what they call a ſubſtance they make indeed an accident, and beſides contradict their own vulgar doctrine, that natural things are upon their corruption reſolved into the firſt matter; ſince, at this rate they ſhould ſay, that ſuch things are but partly reſolved into the firſt matter, and partly either into nothing, or into forms, which being as well immaterial as the ſouls of men, muſt, for aught appears, be alſo, like them, accounted immortal.

I SHOULD now examine thoſe arguments, that are wont to be imployed by the ſchools to evince their ſubſtantial forms; but, beſides that the nature and ſcope of my preſent work enjoins me brevity, I confeſs, that, one or two excepted, the arguments I have found mentioned, as the chief, are rather metaphyſical, or logical, than grounded upon the principles and phænomena of nature, and reſpect rather words than things; and therefore I, who have neither inclination nor leiſure to wrangle about terms, ſhall content my ſelf to propoſe, and very briefly anſwer two or three of thoſe, that are thought the plauſibleſt.

FIRST then they thus argue, *Omne compoſitum ſubſtantiale* (for it is hard to Engliſh well ſuch uncouth terms) *requirit materiam & formam ſubſtantialem, ex quibus componatur. Omne corpus naturale eſt compoſitum ſubſtantiale: ergo*, &c. In this ſyllogiſm ſome do plauſibly enough deny the conſequence, but for brevity's ſake, I ſhall rather chuſe to deny the minor, and deſire the propoſers to prove it. For I know not any thing in nature, that is compoſed of matter, and a ſubſtance diſtinct from matter, except man, who alone is made up of an immaterial form, and a human body: and if it be urged, that then other bodies cannot be properly ſaid to be *compoſita ſubſtantialia*, I ſhall, rather than wrangle with them, give them leave to find out ſome other name for other natural things.

BUT then they argue, in the next place, that, if there were no ſubſtantial forms, all bodies would be but *entia per accidens*, as they ſpeak, which is abſurd. To which I anſwer, that in the notion, that divers learned men have of an *ens per accidens*, namely,* that it is that, which conſiſts of thoſe things, *quæ non ordinantur ad unum*, it may be ſaid, that though we do not admit ſubſtantial forms, yet we need not admit natural bodies to be *entia per accidens*; becauſe in them the ſeveral things, that concur to conſtitute the body, as matter, ſhape, ſituation, and motion, *ordinantur per ſe & intrinſicè* to conſtitute one natural body. But, if this anſwer ſatisfy not, I ſhall add, that for my part, that which I am ſollicitous about, is what nature hath made things to be in themſelves, not what a logician or metaphyſician will call them in the terms of his art; it being much fitter in my judgment to alter words, that they may better fit the nature of things, than to affix a wrong nature to things, that they may be accommodated to forms of words, that were probably deviſed, when the things themſelves were not known or well underſtood, if at all thought on.

WHEREFORE I ſhall but add one argument more of this ſort; and that is, that if there were no ſubſtantial forms, neither could there be any ſubſtantial definitions; but the conſequent is abſurd, and therefore ſo is the antecedent. To which I reply, that ſince the Peripateticks themſelves confeſs the forms of bodies to be of themſelves unknown, all that this argument ſeems to me to conclude, is but this, that if we do not admit ſome things, that are not *in rerum naturâ*, we cannot build our definitions upon them: nor indeed could we, if we ſhould admit ſubſtantial forms, give ſubſtantial definitions of natural things, unleſs we could alſo define natural bodies by things that we know not; for ſuch * the ſubſtantial forms are (as we have ſeen already) confeſſed to be, by the wiſeſt Peripateticks, who pretend not to give the ſubſtantial definition of any natural *compoſitum*, except man. But it may ſuffice us to have, inſtead of ſubſtantial, eſſential definitions of things; I mean, ſuch as are taken from the eſſential differences of things, which conſtitute them in ſuch a ſort of natural bodies, and diſcriminate them from all thoſe of any other ſort.

THESE

* *Nego tibi ullam eſſe formam nobis notam plenè & planè, noſtramque ſcientiam eſſe umbram in ſole.* Scalig.

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THESE three arguments, *Pyrophilus*, for ſubſtantial forms, you may poſſibly, as well as I, find variouſly propoſed, and perhaps with ſome light alterations multiplied in the writings of the Peripateticks and ſchoolmen; but all the arguments of this kind, that I have met with, may, if I miſtake not, be ſufficiently ſolved by the anſwers we have given to theſe, or at leaſt by the grounds, upon which thoſe anſwers are built; thoſe ſeemingly various arguments agreeing in this, that either they reſpect rather words than things, or that they are grounded upon precarious ſuppoſitions; or laſtly, that they urge that as an abſurdity, which, whether it be one or not in thoſe, that admit the Peripatetick philoſophy, to me, that do as little acquieſce in many of their other principles, as I do in their ſubſtantial forms, doth not appear any abſurdity at all. And it is perhaps for fear, that arguments of this ſort ſhould not much prevail with naturaliſts, that ſome of the modern aſſertors of the forms we queſtion, have thought it requiſite to add ſome more phyſical arguments, which (though I have not found them all in the ſame writers, yet) being in all but few, I ſhall here briefly conſider them.

FIRST then, among the phyſical arguments, that are brought to prove ſubſtantial forms, I find that the moſt confidently inſiſted on, which is taken from the ſpontaneous return of heated water to coldneſs; which effects, ſay they, muſt neceſſarily be aſcribed to the action of the ſubſtantial form, whoſe office it is to preſerve the body in its natural ſtate, and, when there is occaſion, to reduce it thereunto: and the argument indeed might be plauſible, if we were ſure, that heated water would grow cold again (without the avolation of any parts more agitated than the reſt,) ſuppoſing it to be removed into ſome of the imaginary ſpaces beyond the world; but, as the caſe is, I ſee no neceſſity of flying to a ſubſtantial form, the matter ſeeming to be eaſily explicable otherwiſe. The water we heat is ſurrounded with our air, or with ſome veſſel, or other body contiguous to the air, and both the air and the water in theſe climates are moſt commonly leſs agitated than the juices in our hands, or other organs of touching, which makes us eſteem and call thoſe fluids, cold. Now when the water is expoſed to the fire, it is thereby put into a new agitation, more vehement than that of the parts of our ſenſory, which you will eaſily grant, if you conſider, that when the heat is intenſe, it makes the water boil and ſmoke, and oftentimes run over the veſſel; but when the liquor is removed from the fire, this acquired agitation muſt needs by degrees be loſt, either by the avolation of ſuch fiery corpuſcles as the Epicureans imagine to be got into heated water, or by the water's communicating the agitation of its parts to the contiguous air, or to the veſſel that contains it, till it have loſt its ſurpluſage of motion, or by the ingreſs of thoſe frigorifick atoms, wherewith (if any ſuch be to be granted) the air in theſe climates is wont to abound, and ſo be reduced into its former temperature: which may as well be done without a ſubſtantial form, as if a ſhip ſwimming ſlowly down a river, ſhould by a ſudden guſt of wind, blowing the ſame way the ſtream runs, be driven on much faſter than before, the veſſel upon the ceaſing of the wind may, without any ſuch internal principle, return after a while to its former ſlowneſs of motion. So that in this phænomenon, we need not have recourſe to an internal principle, the temperature of the external air being ſufficient to give an account of it. And if water be kept, (as is uſual in poor men's houſes, that want cellars,) in the upper rooms of the houſe, in caſe the climate be hot, the water will, in ſpite of the form, continue far leſs cold, than, according to the Peripateticks, its nature requires, all the ſummer long. And let me here repreſent to the champions of forms, that, according to their doctrine, the fluidity of water muſt at leaſt as much proceed from its form, as the coldneſs; and yet this does ſo much depend upon the temperature of the air, that in *Nova Zembla* vaſt quantities of water are kept in the hard and ſolid form of ice all the year long by the ſharp cold of the ambient air, notwithſtanding all the pretended office and power of the ſubſtantial form to keep it fluid; which it will never be reduced to be, unleſs by ſuch a thawing temperature of the air, as would it ſelf, for aught appears, make it flow again, although there were no ſubſtantial form *in rerum naturâ*.

THERE is another argument much urged of late by ſome learned men, the ſubſtance whereof is this, that matter being indifferent to one ſort of accidents as well as to another, it is neceſſary there ſhould be a ſubſtantial form to keep thoſe accidents, which are ſaid to conſtitute it, united to the matter they belong to, and preſerve both them and the body in their natural ſtate: for ſince it is confeſſed, that matter hath no appetite to theſe accidents more than to any others, they demand, how without a ſubſtantial form theſe accidents can be contained and preſerved? To this I might repreſent, that I am not ſo well ſatisfied with the notion wont to be taken for granted, not only by the vulgar, but by philoſophers, of the natural ſtate of bodies; as if it were undeniable, that every natural body (for as to ſome I ſhall not now queſtion it) has a certain ſtate, wherein nature endeavours to preſerve it, and out of which it cannot be put, but by being put into a preternatural ſtate. For the world being once conſtituted by the great author of things as it now is, I look upon the phænomena of nature to be cauſed by the local motion of one part of matter hitting againſt another, and am not ſo fully convinced, that there is ſuch a thing as nature's deſigning to keep ſuch a parcel of matter in ſuch a ſtate, that is clothed with juſt ſuch accidents, rather than with any other. But I look upon many bodies, eſpecially fluid ones, as frequently changing their ſtate, according as they happen to be more or leſs agitated, or otherwiſe wrought upon by the ſun, and other conſiderable agents in nature. As the air, water, and

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and other fluids, if the temperature, as to cold, or heat and rarefaction or condenſation, which they are in at the beginning of the ſpring here at *London*, be pitched upon as their natural ſtate; then not only in the torrid and frozen zones they muſt have other and very differing natural ſtates, but here it ſelf they will almoſt all the ſummer and all the winter (as our weather-glaſſes inform us) be in a varying preternatural ſtate, becauſe they will be in thoſe ſeaſons either more hot and rarified, or more cold and condenſed, than in the beginning of the ſpring. And in more ſtable and conſtant bodies, I take in many caſes the natural ſtate to be but either the moſt uſual ſtate, or that, wherein that, which produces a notable change in them, finds them. As when a ſlender piece of ſilver, that is moſt commonly flexible, and will ſtand bent every way, comes to be well hammered, I count that flexibility to be the natural ſtate of that metal, becauſe moſt commonly ſilver is found to be flexible, and becauſe it was ſo before it was hammered; but the ſpringineſs it acquires by hammering is a ſtate, which is properly no more unnatural to the ſilver than the other, and would continue with the metal as long as it, if both pieces of ſilver, the one flexible, the other ſpringy, were let alone and kept from outward violence. And as the ſilver, to be deprived of its flexibleneſs, needed the violent motion of the hammer, ſo to deprive it of its ſpring it needs the violent agitation of a nealing fire. Theſe things and much more I might here repreſent; but to come cloſe to the objection, I anſwer, that the accidents ſpoken of are introduced into the matter by the agents or efficient cauſes, whatever they be, that produce in it what (in the ſenſe formerly explained) we call an eſſential (though not a ſubſtantial) form. And theſe accidents being once thus introduced into the matter, we need not ſeek for a new ſubſtantial principle to preſerve them there, ſince by the general law or common courſe of nature the matter qualified by them muſt continue in the ſtate ſuch accidents have put it into, till by ſome agent or other it be forcibly put out of it, and ſo diveſted of thoſe accidents: as in the formerly mentioned example, borrowed from *Ariſtotle*, of a brazen ſphere, when once the motion of tools, impelled and guided by the artificer, have turned a piece of braſs into a ſphere, there needs no new ſubſtance to preſerve that round figure, ſince the braſs muſt retain it, till it be deſtroyed by the artificer himſelf, or ſome other agent able to overcome the reſiſtance of the matter to be put into another figure. And on this occaſion let me confirm this *ad hominem*, by repreſenting, that there is not an inconſiderable party among the Peripateticks themſelves, who maintain, that in the elements the firſt qualities (as they call them) are inſtead of forms, and that the fire (for inſtance) hath no other form than heat and dryneſs, and the water than coldneſs and moiſture. Now if theſe bodies, that are the vaſteſt and the moſt important of the ſublunary world, conſiſt but of the univerſal matter and the few accidents; and if in theſe there needs no ſubſtantial form to keep the qualities of the matter united to it, and conjoined among themſelves, and preſerve them in that ſtate as long as the law of nature requires; though beſides the four qualities, that are called firſt, the elements have divers others, as gravity and levity, firmneſs and fluidity, opacouſneſs and tranſparency, *&c.* why ſhould the favourers of this opinion deny, that in other bodies beſides the elements, qualities may be preſerved and kept united to the matter they belong to, without the band or ſupport of a ſubſtantial form? And as, when there is no competent deſtructive cauſe, the accidents of a body will by the law of nature remain ſuch as they were; ſo if there be, it cannot with reaſon be pretended, that the ſubſtantial form is able to preſerve all thoſe accidents of a body, that are ſaid to flow from it, and to be as it were under its care and tuition. For if, for inſtance, you expoſe a ſphere or bullet of lead to a ſtrong fire, it will quickly loſe (not to mention its figure) both its coldneſs, its conſiſtence, its malleableneſs, its colour, (for it will appear of the colour of fire,) its flexibility, and ſome other qualities; and all this in ſpite of the imaginary ſubſtantial form, which, according to the Peripatetical principles, in this caſe muſt ſtill remain in it without being able to help it. And though upon the taking the lead from off the fire, it is wont to be educed to moſt of its former qualities, (for it will not of it ſelf recover its ſphericity,) yet that may well be aſcribed partly to its peculiar texture, and partly to the coldneſs of the ambient air, according to what we lately diſcourſed touching heated and refrigerated water; which temperature of the air is an extrinſecal thing to the lead, and indeed it is but accidental, that the lead upon refrigeration regains its former qualities: for in caſe the lead have been expoſed long enough to a ſufficiently intenſe fire, it will (as we have purpoſely tried) be turned into glaſs, and loſe its colour, its opacity, its malleableneſs, and (former degree of) flexibleneſs, and acquire a reddiſhneſs, a degree of tranſparency, a brittleneſs, and ſome other qualities that it had not before: and let the ſuppoſed ſubſtantial form do what it can, even when the veſſel is removed from the fire, to reduce or reſtore the body to its natural ſtate and accidents, yet the former qualities will remain loſt, as long as theſe preternatural ones introduced by the fire continue in the matter; and neither the one will be reſtored, nor the other deſtroyed, till ſome ſufficiently powerful extrinſick agent effect the change. And on the other ſide I conſider, that the fruit, when ſever'd from the tree it grew on, is confeſſed to be no longer animated (at leaſt the kernels or ſeeds excepted) by the vegetative ſoul or ſubſtantial form of the plant; yet in an orange or lemon (for inſtance) plucked from the tree, we ſee, that the ſame colour, the ſame odour, the ſame taſte, the ſame figure, the ſame conſiſtence, and, for aught we know,

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the ſame other qualities, whether ſenſible or even occult, as are its antidotal and antiſcorbutical virtues, that muſt before be ſaid to have flowed from the ſoul of the tree, will continue many months, perhaps ſome years, after the fruit has ceaſed to have any commerce with the tree, (nay, though the tree, whereon it grew, be perhaps in the mean time hewn down or burnt, and though conſequently its vegetative ſoul or form be deſtroyed,) as when it grew thereon, and made up one plant with it. And we find, that tamarinds, rhubarb, ſenna, and many other ſimples will, for divers years after they have been deprived of their former vegetative ſoul, retain their purgative and other ſpecifick properties.

I FIND it likewiſe urged, that there can be no reaſon, why whiteneſs ſhould be ſeparable from a wall, and not from ſnow or milk; unleſs we have recourſe to ſubſtantial forms. But in caſe men have agreed to call a thing by ſuch a name, becauſe it has ſuch a particular quality, that differences it from others, we need go no farther to find a reaſon, why one quality, is eſſential to one thing, and not to another. As in our former example of a braſs ſphere, the figure is that, for which we give it that name; and therefore, though you may alter the figure of the matter, yet by that very alteration the body periſhes in the capacity of a ſphere, whereas its coldneſs may be exchanged for heat, without the making it the leſs a ſphere, becauſe it is not for any ſuch quality, but for roundneſs, that a body is ſaid to be a ſphere. And ſo firmneſs is an inſeparable quality of ice, though this or that particular figure be not, becauſe that it is for want of fluidity, that any thing, that was immediately before a liquor, is called ice; and congruouſly hereunto, though whiteneſs were inſeparable from ſnow and milk, yet that would not neceſſarily infer, that there muſt be a ſubſtantial form to make it ſo: for the firmneſs of the corpuſcles, that compoſe ſnow, is as inſeperable from it as the whiteneſs; and yet it is not pretended to be the effect of the ſubſtantial form of the water, but of the exceſs of the coldneſs of the air, which (to uſe vulgar, though perhaps unaccurate expreſſions) puts the water out of its natural ſtate of fluidity, and into a preternatural one of firmneſs and brittleneſs. And the reaſon, why ſnow ſeldom loſes its whiteneſs but with its nature, ſeems to be, that its component particles are ſo diſpoſed, that the ſame heat of the ambient air, that is fit to turn it into a tranſparent body, is alſo fit to make it a fluid one, which when it is become, we no longer call it ſnow, but water; ſo that the water loſes its whiteneſs, though the ſnow do not. But if there be a cauſe proper to make a convenient alteration of texture in the ſnow, without melting or reſolving it into water, it may then exchange its whiteneſs for yellowneſs, without loſing its right to be called ſnow: as I remember I have read in an eminent writer, that *de facto* in the northern regions towards the pole, thoſe parcels of ſnow, that have lain very long on the ground, degenerated in time into a yellowiſh colour, very differing from that pure whiteneſs to be obſerved in the neighbouring ſnow lately fallen.

BUT there yet remains an argument for ſubſtantial forms, which, though (perhaps becauſe phyſical) wont be overlooked or ſlightly anſwered by their oppoſers, will for the ſame reaſon deſerve to be taken notice of here; and it is, that there ſeems to be a neceſſity of admitting ſubſtantial forms in bodies, that from thence we may derive all the various changes, to which they are ſubject, and the differing effects they produce, the preſervation and reſtitution of the ſtate requiſite to each particular body, as alſo the keeping of its ſeveral parts united into one *totum*. To the anſwering of this argument ſo many things will be found applicable both in the paſt and ſubſequent parts of theſe notes, that I ſhall at preſent but point the chief particulars, on which the ſolution is grounded.

I CONSIDER then firſt, that many and great alterations may happen to bodies, which ſeem manifeſtly to proceed from their peculiar texture, and the action of outward agents upon them, and of which it cannot be ſhewn, that they would happen otherwiſe, though there were no ſubſtantial forms *in rerum naturâ*: as we ſee, that tallow (for inſtance) being melted by the fire, loſes is coldneſs, firmneſs, and its whiteneſs, and acquires heat, fluidity, and ſome tranſparency; all which being ſuffered to cool, it preſently changes for the three firſt named qualities. And yet divers of theſe changes are plainly enough the effects partly of the fire, partly of the ambient air, and not of I know not what ſubſtantial form: and as it is both evident and remarkable, what great variety of changes in qualities, and productions in new ones, the fire (that is, a body conſiſting of inſenſible parts, that are variouſly and vehemently moved) doth effect by its heat, that is, by a modified local motion; I conſider further, that various operations of a body may be derived from the peculiar texture of the whole, and the mechanical affections of the particular corpuſcles or other parts, that compoſe it, as we have often occaſion to declare here and there in this treatiſe; and particularly by an inſtance, ere long to be further inſiſted on, namely, that though vitriol made of iron with a corroſive liquor be but a factitious body, made by a convenient appoſition of the ſmall parts of the ſaline menſtruum to thoſe of the metal, yet this vitriol will do moſt, if not all, of the ſame things, that vitriol made by nature in the bowels of the earth, and digged out thence, will perform: and each of theſe bodies may be endowed with variety of differing qualities, which I ſee not, why they muſt flow in the native vitriol from a ſubſtantial form, ſince in the factitious vitriol the ſame qualities belong to a form, that does plainly emerge from the coalition of metalline and ſaline corpuſcles, aſſociated together, and diſpoſed of after a certain manner.

AND laſtly, as to what is very confidently, as well as plauſibly pretended, That a ſub-

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ſtantial form is requiſite to keep the parts of a body united, without which it would not be one body; I anſwer, That the contrivance of conveniently figured parts; and in ſome caſes their juxta-poſition, may, without the aſſiſtance of a ſubſtantial form, be ſufficient for this matter. For not to repeat what I juſt now mentioned concerning vitriol made by art, whoſe parts are as well united and kept together, as thoſe of the native vitriol, I obſerve, that a pear grafted upon a thorn, or a plumb inoculated upon an apricock, will bear good fruit, and grow up with the ſtock, as though they both made but one tree, and were animated but by the ſame common form; whereas indeed both the ſtock, and the inoculated or grafted plant, have each of them its own form, as may appear by the differing leaves and fruits, and ſeeds they bear. And that, which makes to our preſent purpoſe, is, that even vegetation and the diſtribution of aliments are in ſuch caſes well made, though the nouriſhed parts of the total plant, if I may ſo call it, have not one common ſoul or form; which is yet more remarkable in the miſletoes, that I have ſeen growing upon old hazle-trees, crab-trees, apple-trees, and other plants, in which the miſletoe often differs very widely from that kind of plant, on which it grows and proſpers. And for the durableneſs of the union betwixt bodies, that a ſubſtantial form is not requiſite to procure it, I have been induced to think, by conſidering, that ſilver and gold, being barely mingled by infuſion, will have their minute parts more cloſely united, than thoſe of any plant or animal, that we know of. And there is ſcarce any natural body, wherein the form makes ſo ſtrict, durable, and indiſſoluble an union of the parts it conſiſts of, as that, which in that factitious concrete we call glaſs, ariſes from the bare commiſtion of the corpuſcles of ſand with thoſe ſaline ones, wherewith they are colliquated by the violence of the fire: and the like may be ſaid of the union of the proper accidents of glaſs with the matter of it, and betwixt one another.

To draw towards a concluſion, I know it is alleged as a main conſideration on the behalf of ſubſtantial forms, that theſe being in natural bodies the true principles of their properties, and conſequently of their operations, their natural philoſophy muſt needs be very imperfect and defective, who will not take in ſuch forms: but for my part I confeſs, that this very conſideration does rather indiſpoſe than incline me to admit them. For if indeed there were in every natural body ſuch a thing as a ſubſtantial form, from which all its properties and qualities immediately flow, ſince we ſee, that the actions of bodies upon one another are for the moſt part (if not all) immediately performed by their qualities or accidents, it would ſcarce be poſſible to explicate very many of the explicable phænomena of nature, without having recourſe to them; and it would be ſtrange, if many of the abſtruſer phænomena were not explicable by them only. Whereas indeed almoſt all the rational accounts to be met with of difficult phænomena, are given by ſuch as either do not acknowledge, or at leaſt do not take notice of ſubſtantial forms. And it is evident by the clear ſolutions (untouched by many vulgar philoſophers,) we meet with of many phænomena in the Staticks, and other parts of the Mechanicks, and eſpecially in the Hydroſtaticks, and Pneumaticks, how clearly many phænomena may be ſolved, without imploying a ſubſtantial form. And on the other ſide, I do not remember, that either *Ariſtotle* himſelf (who perhaps ſcarce ever attempted it,) or any of his followers, has given a ſolid and intelligible ſolution of any one phænomenon of nature by the help of ſubſtantial forms; which you need not think it ſtrange I ſhould ſay, ſince the greateſt patrons of forms acknowledging their nature to be * unknown to us, to explain any effect by a ſubſtantial form, muſt be to declare (as they ſpeak) *ignotum per ignotius*, or at leaſt *per æquè ignotum*. And indeed to explicate a phænomenon being to deduce it from ſomething elſe in nature, more known to us than the thing to be explained by it, how can the imploying of incomprehenſible (or at leaſt uncomprehended) ſubſtantial forms, help us to explain intelligibly this or that particular phænomenon? For to ſay, that ſuch an effect proceeds not from this or that quality of the agent, but from its ſubſtantial form, is to take an eaſy way to reſolve all difficulties in general, without rightly reſolving any one in particular; and would make a rare philoſophy, if it were not far more eaſy than ſatisfactory: for if it be demanded, why jet attracts ſtraws, rhubarb purges choler, ſnow dazzles the eyes rather than graſs, *&c.* to ſay, that theſe and the like effects are performed by the ſubſtantial forms of the reſpective bodies, is at beſt but to tell me, what is the agent, not how the effect is wrought; and ſeems to be but ſuch a kind of general way of anſwering, as leaves the curious inquirer as much to ſeek for the cauſes and manner of particular things, as men commonly are for the particular cauſes of the ſeveral ſtrange things performed by witchcraft, though they be told, that it is ſome devil, that does them all. Wherefore I do not think, but that natural philoſophy, without being for that the more defective, may well enough ſpare the doctrine of ſubſtantial forms as an uſeleſs theory; not that men are arrived to be able to explicate all the phænomena of nature without them, but becauſe whatever we cannot explicate without them, we cannot neither intelligibly explicate by them.

AND thus, *Pyrophilus*, I have offered you ſome of thoſe many things, that indiſpoſed me to acquieſce in the received doctrine of ſubſtantial forms; but in caſe any more piercing inquirer ſhall perſuade himſelf, that he underſtands it throughly, and can explicate it clearly, I ſhall congratulate him for ſuch happy

* *Nomina tu lapidis, qui quotidie tuis oculis obſervatur, formam, & Phyllida ſolus habeto.* Scal. contra Card.

by intellectuals, and be very ready to be informed by him. But ſince what the ſchools are wont to teach of the origin and attributes of ſubſtantial forms, is that, which, I confeſs, I cannot yet comprehend; and ſince I have ſome of the eminenteſt perſons among the modern philoſophers to join with me, though perhaps not for the ſame conſiderations, in the like confeſſion, that it is not neceſſary the reaſon of my not finding this doctrine conceivable muſt be rather a defectiveneſs in my underſtanding, than the unconceivable nature of the thing itſelf; I, who love not (in matters purely philoſophical) to acquieſce in what I do not underſtand, nor to go about to explicate things to others by what appears to me itſelf unexplicable, ſhall, I hope, be excuſed, if, leaving thoſe, that contend for them, the liberty of making what uſe they can of ſubſtantial forms, I do, till I be better ſatisfied, decline imploying them myſelf, and endeavour to ſolve thoſe phænomena, I attempt to give an account of, without them; as not ſcrupling to confeſs, that thoſe, that I cannot explicate, at leaſt in a general way, by intelligible principles, I am not yet arrived to the diſtinct and particular knowledge of.

Now for our doctrine touching the origin of forms, it will not be difficult to collect it from what we formerly diſcourſed about qualities and forms together: for the form of a natural body being, according to us, but an eſſential modification, and as it were the ſtamp of its matter; or ſuch a convention of the bigneſs, ſhape, motion, (or reſt,) ſituation and contexture, (together with the thence reſulting qualities) of the ſmall parts, that compoſe the body, as is neceſſary to conſtitute and denominate ſuch a particular body; and all theſe actions being producible in matter by local motion, it is agreeable to our hypotheſis to ſay, that the firſt and univerſal, though not immediate cauſe of forms is none other but God, who put matter into motion, (which belongs not to its eſſence,) and eſtabliſhed the laws of motion amongſt bodies, and alſo, according to my opinion, guided it in divers caſes at the beginning of things; and that, among ſecond cauſes, the grand efficient of forms in local motion, which, by variouſly dividing, ſequeſtring, tranſpoſing, and ſo connecting the parts of matter, produces in them thoſe accidents and qualities, upon whoſe account the portion of matter they diverſify, comes to belong to this or that determinate ſpecies of natural bodies, which yet is not ſo to be underſtood, as if motion were only an efficient cauſe in the generation of bodies, but very often (as in water, fire, &c.) it is alſo one of the chief accidents, that concur to make up the form.

But in this laſt ſummary account of the origin of forms, I think myſelf obliged to declare to you a little more diſtinctly what I juſt now intimated to be my own opinion. And this I ſhall do by advertiſing you, that though I agree with our Epicureans, in thinking it probable, that the world is made up of an innumerable multitude of ſingly inſenſible corpuſcles, endowed with their own ſizes, ſhapes, and motions; and though I agree with the Carteſians, in believing (as I find that * *Anaxagoras* did of old) that matter hath not its motion from it ſelf, but originally from God; yet in this I differ both from *Epicurus* and *Des Cartes*, that whereas the former of them plainly denies, that the world was made by any deity (for deities he owned,) and the latter of them, for aught I can find in his writings, or thoſe of ſome of his eminenteſt diſciples, thought, that God having once put matter into motion, and eſtabliſhed the laws of that motion, needed not more particularly interpoſe for the production of things corporeal, nor even of plants or animals, which, according to him, are but engines: I do not at all believe, that either theſe Carteſian laws of motion, or the Epicurean caſual concourſe of atoms, could bring mere matter into ſo orderly and well-contrived a fabrick as this world. And therefore I think, that the wiſe author of nature did not only put matter into motion, but, when he reſolved to make the world, did ſo regulate and guide the motions of the ſmall parts of the univerſal matter, as to reduce the greater ſyſtems of them into the order they were to continue in; and did more particularly contrive ſome portions of that matter into ſeminal rudiments or principles, lodged in convenient receptacles, (and, as it were, wombs,) and others into the bodies of plants and animals: one main part of whoſe contrivance did, as I apprehend, conſiſt in this, that ſome of their organs were ſo framed, that ſuppoſing the fabrick of the greater bodies of the univerſe, and the laws he had eſtabliſhed in nature, ſome juicy and ſpirituous parts of theſe living creatures muſt be fit to be turned into prolifick ſeeds, whereby they may have a power, by generating their like, to propagate their ſpecies. So that, according to my apprehenſion, it was at the beginning neceſſary, that an intelligent and wiſe agent ſhould contrive the univerſal matter into the world, (and eſpecially ſome portions of it into ſeminal organs and principles,) and ſettle the laws, according to which the motions and actions of its parts upon one another ſhould be regulated: without which interpoſition of the world's architect, however moving matter may, with ſome probability (for I ſee not in the notion any certainty) be conceived to be able, after numberleſs occurſions of its inſenſible parts, to caſt it ſelf into ſuch grand conventions and convolutions as the Carteſians call *vortices*, and (as I remember) † *Epicurus* ſpeaks of under the name of περιελίξεις, καὶ δινήσεις; yet I think it utterly improbable, that brute and unguided, though moving, matter ſhould ever convene into ſuch admirable ſtructures, as the bodies of perfect animals. But the world being once framed, and the courſe of nature eſtabliſhed, the naturaliſt

* *Ariſtotle* ſpeaking of *Anaxagoras*, in the firſt chapter of the laſt book of his Phyſicks, hath this paſſage: *Dicit* (Anaxagoras) *cum omnia ſimul eſſent, atque* quieſcerent *tempore infinito, mentem* moviſſe *ac ſegregaſſe.*

† *Epicurus* in his epiſtle to *Pythocles.*

turaliſt (except in ſome few caſes, where God or incorporeal agents interpoſe,) has recourſe to the firſt cauſe but for its general and ordinary ſupport and influence, whereby it preſerves matter and motion from annihilation or deſition; and in explicating particular phænomena conſiders only the ſize, ſhape, motion, (or want of it,) texture, and the reſulting qualities and attributes of the ſmall particles of matter. And thus in this great automaton, the world, (as in a watch or clock,) the materials it conſiſts of being left to themſelves, could never at the firſt convene into ſo curious an engine: and yet when the ſkilful artiſt has once made and ſet it a going, the phænomena it exhibits are to be accounted for by the number, bigneſs, proportion, ſhape, motion (or endeavour,) reſt, coaptation, and other mechanical affections of the ſpring, wheels, pillars, and other parts it is made up of: and thoſe effects of ſuch a watch, that cannot this way be explicated, muſt, for aught I know, be confeſſed not to be ſufficiently underſtood.

BUT to return thither, whence my duty to the author of nature obliged me to make this ſhort digreſſion:

THE hitherto propoſed hypotheſis, touching the origination of forms, hath, I hope, been rendered probable by divers particulars in the paſt diſcourſes, and will be both exemplified and confirmed by ſome of the experiments, that make the latter part of this preſent treatiſe, (eſpecially the fifth and ſeventh of them,) which, containing experiments of the changing the form of a ſalt and a metal, do chiefly belong to the hiſtorical or experimental part of what we deliver touching the origin of forms. And indeed, beſides the two kinds of experiments preſently to be mentioned, we might here preſent you a third ſort, conſiſting partly of divers relations of metalline tranſmutations, delivered upon their own credit by credible men, that are not alchymiſts; and partly of ſome experiments (ſome made, ſome directed by us) of changing both bodies totally inflammable almoſt totally into water; and a good part even of diſtilled rain water without additament into earth; and diſtilled liquors, readily and totally mingleable with water, *pro parte* into a true oil, that will not mix with it. This ſort of experiments, I ſay, I might here annex, if I thought fit, in this place, either to lay any ſtreſs upon thoſe, that I cannot my ſelf make out, or to transfer hither thoſe experiments of changes amongſt bodies not metalline, that belong to another * treatiſe. But over and above what the paſt notes and the experiments, that are to follow them, contain towards the making of what we teach concerning forms, we will here for further confirmation proceed to add two ſorts of experiments, (beſides the third already mentioned.) The one, wherein it appears, that bodies of very differing natures, being put together, like the wheels and other pieces of a watch, and by their connexion acquiring a new texture, and ſo new qualities, may, without having recourſe to a ſubſtantial form, compoſe ſuch a new concrete, as may as well deſerve to have a ſubſtantial form attributed to it, by virtue of that new diſpoſition of its parts, as other bodies, that are ſaid to be endowed therewith: and the other, that a natural body being diſſipated, and as it were taken in pieces like a watch, may have its parts ſo aſſociated, as to conſtitute new bodies of natures very differing from its own, and from each other; and yet theſe diſſipated and ſcattered parts, by being recollected and put together again like the pieces of a watch, in the like order as before, may recompoſe (almoſt, if not more than almoſt) ſuch another body, as that they made up before they were taken aſunder.

I. EXPERIMENTS *and* THOUGHTS *about the Production and Reproduction of* FORMS.

IT was not at random, that I ſpoke, when, in the foregoing notes about the origin of qualities, I intimated, that it was very much by a kind of tacit agreement, that men had diſtinguiſhed the ſpecies of bodies, and that thoſe diſtinctions were more arbitrary, than we are wont to be aware of. For I confeſs, that I have not yet, either in *Ariſtotle* or any other writer, met with any genuine and ſufficient diagnoſtick and boundary for the diſcriminating and limiting the ſpecies of things; or, to ſpeak more plainly, I have not found, that any naturaliſt has laid down a determinate number and ſort of qualities or other attributes, which is ſufficient and neceſſary to conſtitute all portions of matter, endowed with them, diſtinct kinds of natural bodies. And therefore I obſerve, that moſt commonly men look upon theſe as diſtinct ſpecies of bodies, that have had the luck to have diſtinct names found out for them; though perhaps divers of them differ much leſs from one another than other bodies, which (becauſe they have been huddled up under one name,) have been looked upon as but one ſort of bodies. But not to lay any weight on this intimation about names, I found, that for want of a true characteriſtick or diſcriminating note, it hath been and is ſtill both very uncertain as to divers bodies, whether they are of different ſpecies or of the ſame, and very difficult to give a ſufficient reaſon, why divers bodies, wherein nature is aſſiſted

* The Sceptical Chymiſt.

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aſſiſted by art, ſhould not as well paſs for diſtinct kinds of bodies, as others, that are generally reckoned to be ſo.

WHETHER (for inſtance) water and ice be not to be eſteemed diſtinct kinds of bodies, is ſo little evident, that ſome, that pretend to be very well verſed in *Ariſtotle*'s writings and opinions, affirm him to teach, that water loſes not its own nature by being turned into ice; and indeed I remember I have read a * text of his, that ſeems expreſs enough to this purpoſe, and the thing it ſelf is made plauſible by the reducibleneſs of ice back again into water. And yet I remember, *Galen* is affirmed to make theſe two diſtinct ſpecies of bodies; which doctrine is favoured by the differing qualities of ice and water: for not only the one is fluid, and the other ſolid, and even brittle, but ice is alſo commonly more or leſs opacous in compariſon of water, being alſo lighter than it in ſpecie, ſince it ſwims upon it. To which may be added, that ice beaten with common ſalt will freeze other bodies, when water mingled with ſalt will not. And on this occaſion I would propoſe to be reſolved, whether muſt, wine, ſpirit of wine, vinegar, tartar, and vappa, be ſpecifically diſtinct bodies? and the like queſtions I would aſk concerning a hen's egg, and the chick, that is afterwards hatched out of it; as alſo concerning wood, aſhes, ſoot, and likewiſe the eggs of ſilkworms, which are firſt ſmall caterpillars, or (as ſome think them) but worms, when they are newly hatched, and then aurelia's, (or huſked maggots,) and then butterflies; which I have obſerved with pleaſure to be the ſucceſſive production of the prolifick ſeed of ſilk-worms. And whether the anſwer to theſe queries be affirmative or negative, I doubt the reaſon, that will be given for either of the two, will not hold in divers caſes, whereto I might apply it. And a more puzzling queſtion it may be to ſome, whether a charcoal, being throughly kindled, do ſpecifically differ from another charcoal? For, according to thoſe I argue with, the fire has penetrated it quite through; and therefore ſome of the recent Ariſtotelians are ſo convinced of its being tranſmuted, that all the ſatisfaction I could find from a very ſubtle modern ſchoolman to the objection, that if the glowing coal were plunged into water, it would be a black coal again, was, that, notwithſtanding that reduction, the form of a charcoal had been once aboliſhed by the fire, and was reproduced by God, upon the regained diſpoſition of the matter to receive it.

NOR is it very eaſy to determine, whether clouds, and rain, and hail, and ſnow, be bodies ſpecifically diſtinct from water and from each other, and the writers of meteors are wont to handle them as diſtinct. And if ſuch ſlight differences as thoſe, that diſcriminate theſe bodies, or that, which diſtinguiſhes wind from exhalations, whoſe courſe makes it be ſufficient to conſtitute differing kinds of bodies, it will be hard to give a ſatisfactory reaſon, why other bodies, that differ in more or more conſiderable particulars, ſhould not enjoy the ſame privilege. And I preſume, that ſnow differs leſs from rain, than paper doth from rags, or glaſs made of wood-aſhes does from wood. And indeed men having by tacit conſent agreed to look upon paper, and glaſs, and ſoap, and ſugar, and braſs, and ink, and pewter, and gunpowder, and I know not how many others, to be diſtinct ſorts of bodies, I ſee not, why they may not be thought to have done it on as good grounds, as thoſe, upon which divers other differing ſpecies of bodies have been conſtituted. Nor will it ſuffice to object, that theſe bodies are factitious; for it is the preſent nature of bodies, that ought to be conſidered in referring them to ſpecies, which way ſoever they came by that nature: for ſalt, that is in many countries made by boiling ſea-water in cauldrons and other veſſels, is as well true ſea-ſalt, as that, which is made in the *Iſle of Man*, (as navigators call it,) without any co-operation of man, by the bare action of the ſun upon thoſe parts of the ſea-water, which chance to be left behind in hollow places, after a high ſpring-tide. And ſilkworms, which will hatch by the heat of human bodies, and chickens, that are hatched in *Ægypt* by the heat of ovens or dunghils, are no leſs true ſilkworms or chickens, than thoſe, that are hatched by the ſun or by hens.

As for what may be objected, that we muſt diſtinguiſh betwixt factitious bodies and natural, I will not now ſtay to examine, how far that diſtinction may be allowed: for it may ſuffice for our preſent purpoſe to repreſent, that whatever may be ſaid of factitious bodies, where man does, by inſtruments of his own providing, only give figure, or alſo contexture to the ſenſible (not inſenſible) parts of the matter he works upon; as when a joiner makes a ſtool, or a ſtatuary makes an image, or a turner a bowl: yet the caſe may be very differing in thoſe other factitious productions, wherein the inſenſible parts of matter are altered by natural agents, who perform the greateſt part of the work among themſelves, though the artificer be an aſſiſtant, by putting them together after a due manner. And therefore I know not, why all the productions of the fire made by chymiſts ſhould be looked upon, as not natural, but artificial bodies; ſince the fire, which is the grand agent in theſe changes, doth not, by being employed by the chymiſt, ceaſe to be and to work as a natural agent. And ſince nature her ſelf doth, by the help of the fire, ſometimes afford us the like productions, that the alchymiſt's art preſents us: as in *Ætna*, *Veſuvius*, and other burning mountains, (ſome of whoſe productions I can ſhew you,) ſtones are ſometimes turned into lime, (and ſo an alkalizate ſalt is produced,) and ſometimes, if they be more diſpoſed to be fluxed than calcined,

* See *Lib.* 1. *de Gen. & Corr. t.* 80. *Idem corpus* (ſays he there) *quanquam continuum, aliàs liquidum, aliàs concretum videmus, non diviſione aut compoſitione hoc paſſum, aut converſione, aut attactu, ſicuti* Democritus *aſſerit: nam neque tranſpoſitione, neque* Naturæ demutatione (ὃ τὸ μεταβάλλον τὴν Φύσιν) *ex liquido concretum evadere ſolet.*

cined, brought to vitrification; metalline and mineral bodies are by the violence of the fire colliquated into maſſes of very ſtrange and compounded natures. Aſhes and metalline flowers of divers kinds are ſcattered about the neighbouring places, and copious flowers of ſulphur, ſublimed by the internal fire, have been ſeveral times found about the vents, at which the fumes are diſcharged into the air: (as I have been aſſured by ingenious viſitors of ſuch places, whom I purpoſely inquired of, touching theſe *flores*; for of theſe travellers more than one anſwered me, they had themſelves gathered, and had brought ſome very good.) Not to add, that I have ſometimes ſuſpected, upon no abſurd grounds, that divers of the minerals and other bodies, we meet with in the lower parts of the earth, and think to have been formed and lodged there ever ſince the beginning of things, have been ſince produced there by the help of ſubterraneal fires or other heats, which may either by their immediate action, and exceedingly long application, very much alter ſome bodies by changing their texture; as when lead is turned into minium, and tin into putty, by the operation of the fire in a few hours, or by elevating, in the form of exhalations or vapours, divers ſaline and ſulphureous corpuſcles or particles of unripe, or (to uſe a chymical term of art) embryonated minerals, and perhaps metals, which may very much alter the nature, and thereby vary the kind of other ſubterraneal bodies, which they pervade, and in which they often come to be incorporated; or elſe may, by convening among themſelves, conſtitute particular concretions, as we ſee, that the fumes of ſulphur and thoſe of mercury unite into that lovely red maſs, which in the ſhops they call vermilion, and which is ſo like to the mineral, whence we uſually obtain mercury, that the Latins give them both the ſame name *Cinnabaris*, and in that are imitated by the French and Italians; in whoſe favour I ſhall add, that if we ſuppoſe this mineral to conſiſt of a ſtony concretion, penetrated by ſuch mineral fumes, as I have been ſpeaking of, the appellation may be better excuſed than perhaps you imagine; ſince from *Cinnabaris nativa* not only I obtained a conſiderable quantity of good running mercury, (which is that, men are wont to ſeek for from it,) but to gratify my curioſity ſomewhat further, I tried an eaſy way, that came into my mind, whereby the *caput mortuum* afforded me no deſpicable quantity of good combuſtible ſulphur. But this upon the by, being not obliged to ſet down here the grounds of my paradoxical conjecture about the effects of ſubterraneal fires and heats, ſince I here lay no ſtreſs upon it, but return to what I was ſaying about *Ætna*, and other Volcanos. Since then theſe productions of the fire, being of nature's own making, cannot be denied to be natural bodies, I ſee not, why the like productions of the fire ſhould be thought unworthy that name, only becauſe the fire, that made the former, was kindled by chance in a hill, and that, which produced the latter, was kindled by a man in a furnace. And if flower of ſulphur, lime, glaſs, and colliquated mixtures of metals and minerals are to be reckoned among natural bodies, it ſeems to be but reaſonable, that, upon the ſame grounds, we ſhould admit flower of antimony, lime, and glaſs, and pewter, and braſs, and many other chymical concretes, (if I may ſo call them) to be taken into the ſame number; and then it will be evident, that to diſtinguiſh the ſpecies of natural bodies, a concourſe of accidents will, without conſidering any ſubſtantial form, be ſufficient.

BUT becauſe I need not, on this occaſion, have recourſe to inſtances of a diſputable nature, I will pitch, for the illuſtration of the mechanical production of forms, upon vitriol. For ſince nature herſelf, without the help of art, does oftentimes produce that concrete, (as I have elſewhere ſhewn by experience,) there is no reaſon, why vitriol, produced by eaſy chymical operations, ſhould not be looked upon as a body of the ſame nature and kind. And in factitious vitriol, our knowing what ingredients we make uſe of, and how we put them together, enables us to judge very well how vitriol is produced. But becauſe it is wont to be reckoned with ſalt-petre, ſea-ſalt, and ſal-gem, among true ſalts, I think it requiſite to take notice, in the firſt place, that vitriol is not a mere ſalt, but that, which *Paracelſus* ſomewhere, and after him divers other Spagyriſts call a *magiſtery*, which in their ſenſe (for there are, that uſe it in another,) commonly ſignifies a preparation, wherein the body to be prepared has not its principles ſeparated; as in diſtillation, incineration, *&c.* but wherein the whole body is brought into another form, by the addition of ſome ſalt or menſtruum, that is united *per minima* with it. And agreeably to this notion we find, that from common vitriol, whether native or factitious, may be obtained (by diſtillation and reduction) an acid ſaline ſpirit, and a metalline ſubſtance, as I elſewhere mention, that from blue vitriol copper may be (by more than one way) ſeparated. And I the rather give this advertiſement, becauſe that as there is a vitriol of iron, which is uſually green, and another of copper, which is wont to be blue, and alſo a white vitriol, about which it is diſputed what it holds, (though that it holds ſome copper, I have found;) and yet of all theſe are without ſcruple reputed true vitriols, notwithſtanding that they differ ſo much in colour, and (as I have diſcovered) in ſeveral other qualities; ſo I ſee no reaſon, why the other minerals, being reduced by their proper menſtruums into ſalt like magiſteries, may not paſs for the vitriols of thoſe metals, and conſequently for natural bodies: which, if granted, will add ſome confirmation to our doctrine, though its being granted is not neceſſary to make it out. For to confine ourſelves to vitriol, it is known among chymiſts, that if upon the filings of *Mars* one put a convenient quantity of that acid diſtilled liquor, which is (abuſively) wont to be called oil of vitriol, diluting the mixture with rain or with common water, it is

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is eaſy by filtrating the ſolution, by evaporating the aqueous ſuperfluity of it, and by leaving the reſt for a competent while in a cellar, (or other cold place) to cryſtallize; it is eaſy, I ſay, by this means to obtain a vitriol of iron; which agrees with the other vitriol of vitriol-ſtones or marchaſites, preſented us by nature, without the help of any other menſtruum, than the rain, that falls upon them from the clouds, in I know not how many qualities, part obvious, and part of them occult: as, (of the firſt ſort) in colour, tranſparency, brittleneſs, eaſineſs of fuſion, ſtyptical taſte, reducibleneſs to a red powder by calcination, and other qualities more obvious to be taken notice of; to which may be annexed divers qualities of the ſecond ſort, (I mean the more abſtruſe ones,) as the power to turn in a trice an infuſion of galls, made in ordinary water, (as alſo to turn a certain clear mineral ſolution, elſewhere mentioned,) into an inky colour; to which, in all probability, we may add a faculty of cauſing vomits even in a ſmall doſe, when taken into the ſtomach of a man, and that remarkable property of being endowed with as exact and curious a ſhape or figure, as thoſe, for which ſalts have been, by modern philoſophers eſpecially, ſo much admired. But, that no ſcruple might ariſe from hence, that in the *vitriolum martis* wont to be made by chymiſts, the menſtruum, that is employed, is the oil of common vitriol, which may be ſuſpected to have retained the nature of the concrete whence it proceeded; and ſo this factitious vitriol may not be barely a new production, but partly a recorporification, as they ſpeak, of the vitriolate corpuſcles contained in the menſtruum: to prevent this ſcruple, I ſay, (which yet perhaps would not much trouble a conſidering chymiſt) I thought fit to employ a quite other menſtruum, that would not be ſuſpected to have any thing of vitriol in it. And though aqua fortis and ſpirit of nitre, however they corrode *Mars*, are unfit for ſuch a work; yet having pitched upon ſpirit of ſalt inſtead of oil of vitriol, and proceeding the ſame way, that has been already ſet down, it anſwered our expectation, and afforded us a good green vitriol. Nor will the great diſpoſition I have obſerved in this our vitriol to reſolve, by the moiſture of the air, into a liquor, make it eſſentially differing from other vitriols, ſince it has been obſerved, and particularly by *Guntherus Belichius* more than once, that even the common vitriol he uſed in *Germany*, will alſo, though not ſo eaſily as other ſalts, run (as the chymiſts phraſe it) *per deliquium*. And to make the experiment more compleat, though we did not find either oil of vitriol, or ſpirit of ſalt, good menſtruums to make a blue venereal vitriol out of copper, (however filed or thinly laminated,) and though upon more trials than one, it appeared, that aqua fortis and ſpirit of nitre, which we thought fit to ſubſtitute to the above mentioned liquors, did indeed make a ſolution of copper, but ſo unctuous a one, that it was very hard to bring any part of it to dryneſs, without ſpoiling the colour and ſhape of the deſired body: yet repeating the experiment with care and watchfulneſs, we, this way, obtained one of the lovelieſt vitriols, that hath perhaps been ſeen, and of which you yourſelf may be the judge by a parcel of it I keep by me for a rarity.

To apply now theſe experiments, eſpecially that, wherein ſpirit of ſalt is employed, to the purpoſe, for which I have mentioned them, let us briefly conſider theſe two things; the one, that our factitious vitriol is a body, that, as well as the natural, is endowed with many qualities, (manifeſt and occult,) not only ſuch as are common to it with other ſalts, as tranſparency, brittleneſs, ſolubleneſs in water, *&c.* but ſuch as are properties peculiar to it, as greenneſs, eaſineſs of fuſion, ſtypticity of taſte, a peculiar ſhape, a power to ſtrike a black with infuſion of galls, an emetick faculty, *&c.*

THE other thing we are to conſider is, that though theſe qualities are in common vitriol believed to flow from the ſubſtantial form of the concrete; and may as juſtly as the qualities, whether manifeſt or occult, of other inanimate bodies, be employed as arguments to evince ſuch a form: yet in our vitriol, made with ſpirit of ſalt, the ſame qualities and properties were produced by the aſſociating and juxta-poſition of the two ingredients, of which the vitriol was compounded; the myſtery being no more but this, that the ſteel being diſſolved in the ſpirit, the ſaline particles of the former, and the metalline ones of the latter having each their determinate ſhapes, did, by their aſſociation, compoſe divers corpuſcles of a mixed or compounded nature, from the convention of many whereof there reſulted a new body of ſuch a texture, as qualified it to affect our ſenſories, and work upon other bodies, after ſuch a manner as common vitriol is wont to do. And indeed in our caſe, not only it cannot be made appear, that there is any ſubſtantial form generated anew, but that there is not ſo much as an exquiſite mixture, according to the common notion the ſchools have of ſuch a mixture. For both the ingredients retain their nature, (though perhaps ſomewhat altered,) ſo that there is, as we were ſaying, but a juxta-poſition of the metalline and ſaline corpuſcles; only they are aſſociated ſo, as by the manner of their coalition to acquire that new texture, which denominates the magiſtery they compoſe, vitriol. For it is evident, that the ſaline ingredient may either totally, or for much the greateſt part be ſeparated by diſtillation, the metalline remaining behind. Nay, ſome of the qualities we have been aſcribing to our vitriol, do ſo much depend upon texture, that the very beams of the ſun (converged) will, as I have purpoſely tried, very eaſily alter its colour, as well as ſpoil its tranſparency, turning it at firſt from green to white; and, if they be concentred by a good burning-glaſs, making it change that livery for a deep red.

DOUBTS

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DOUBTS and EXPERIMENTS *touching the curious Figures of* SALTS.

AND here let me take notice, that though the exact and curious figures, in which vitriol and other ſalts are wont to ſhoot, be made arguments of the preſence, and great inſtances of the plaſtick ſkill of ſubſtantial forms and ſeminal powers; yet, I confeſs, I am not ſo fully ſatisfied in this matter, as even the modern philoſophers appear to be. It is not, that I deny, that *Plato*'s excellent ſaying, γεωμετρεῖ ὁ θεὸς, may be applied to theſe exquiſite productions of nature. For though God has thought fit to make things corporeal after a much more facile and intelligible way, than by the intervention of ſubſtantial forms; and though the plaſtick power of ſeeds, which in plants and animals I willingly admit, ſeem not in our caſe to be needful; yet is the divine architect's geometry (if I may ſo call it) nevertheleſs to be acknowledged and admired. For having been pleaſed to make the primary and inſenſible corpuſcles of ſalts and metals of ſuch determinate, curious, and exact ſhapes, that as they happen to be aſſociated together, they ſhould naturally produce concretions; which, though differingly figured, according to the reſpective natures of their ingredients, and the various manners of their convening, ſhould yet be all of them very curious, and ſeem elaborate in their kinds. How little I think is fit to be allowed, that the bodies of animals, which conſiſt of ſo many curiouſly framed and wonderfully adapted organical parts, (and whoſe ſtructure is a thouſand times more artificial than that of ſalts and ſtones, and other minerals,) can be reaſonably ſuppoſed to have been produced by chance, or without the guidance of an intelligent author of things, I have elſewhere largely declared. But I confeſs I look upon theſe figures we admire in ſalts, and in ſome kinds of ſtones, (which I have not been incurious to collect,) as textures ſo ſimple and ſlight, in compariſon of the bodies of animals, and oftentimes in compariſon of ſome one organical part, that I think it cannot be in the leaſt inferred, that becauſe ſuch ſlight figurations need not be aſcribed to the plaſtick power of ſeeds, it is not neceſſary, that the ſtupendous and incomparably more elaborate fabrick and ſtructure of animals themſelves ſhould be ſo. And this premiſed, I ſhall add, that I have been inclined to the conjecture about the ſhapes of ſalts, that I lately propoſed by theſe conſiderations.

FIRST, That by a bare aſſociation of metalline and ſaline corpuſcles, a concrete, as finely figured as other vitriols, may be produced, as we have lately ſeen.

SECONDLY, Becauſe that the figures of theſe ſalts are not conſtantly in all reſpects the ſame, but may in divers manners be ſomewhat varied, as they happen to be made to ſhoot more haſtily or more leiſurely, and as they ſhoot in ſcanter or fuller proportion of liquor. This may be eaſily obſerved by any, that will but with a little attention conſider the difference, that may be found in vitriolate cryſtals or grains, when quantities of them were taken out of the great coolers, as they call them, wherein that ſalt, at the works where it is boiled, is wont to be ſet to ſhoot. And accordingly where the experienced mineraliſt *Agricola* deſcribes the ſeveral ways of making vitriol in great quantities, he does not only more than once call the great grains or cryſtals, into which it coagulates, cubes; but ſpeaking of the manner of their concretion about the cords or ropes, that are wont (in *Germany*) to be hanged from certain croſs-bars into the vitriolate water or ſolution for the vitriol to faſten it ſelf to, he compares the concretions indifferently to cubes or cluſters of grapes: *Ex his* (ſays he, ſpeaking of the croſs-bars) *pendent reſtes lapillis extentæ, ad quos humor ſpiſſus adhæreſcens denſatur in tranſlucentes atramenti ſutorii vel cubos, vel acinos, qui uvæ ſpeciem gerunt* *. I remember alſo, that having many years ſince a ſuſpicion, that the reaſon, why alkalies, ſuch as ſalt of tartar and pot-aſhes, are wont to be obtained in the form of white powders or calces, might be the way, wherein the water or the lixiviums, that contain them, is wont to be drawn off; I fancied, that by leaving the ſaline corpuſcles a competent quantity of water to ſwim in, and allowing them leiſure for ſuch a multitude of occurſions, as might ſuffice to make them hit upon more congruous coalitions than is uſual, I might obtain cryſtals of them, as well as of other ſalts: conjecturing this, I ſay, I cauſed ſome well purified alkalies diſſolved in clear water to be ſlowly evaporated, till the top was covered with a thin ice-like cruſt; then taking care not to break that, leſt they ſhould (as in the ordinary way, where the water is all forced off,) want a ſufficient ſtock of liquor, I kept them in a very gentle heat for a good while; and then breaking the above mentioned ice-like cake, I had, as I wiſhed, divers figured lumps of cryſtalline ſalt ſhot in the water, and tranſparent almoſt like white ſugar-candy.

I LIKEWISE remember, that having on ſeveral occaſions diſtilled a certain quantity of oil of vitriol with a ſtrong ſolution of ſea-ſalt, till the remaining matter was left dry, that ſaline reſidue being diſſolved in fair water, filtered, and gently evaporated, would ſhoot into cryſtals, ſometimes of one figure, ſometimes of another, according as the quantity or ſtrength of the oil of vitriol and other ſubſtances determined. And yet theſe cryſtals, though ſometimes they would ſhoot into priſm-like figures, as roched petre; and ſometimes into ſhapes more like to allom or vitriol; nay, though oftentimes the ſame

* *Georg. Agricola de re metall.* lib. 12. p. 462.

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caput mortuum diſſolved would in the ſame glaſs ſhoot into cryſtals, whereof ſome would be of one ſhape, ſome of another; yet would theſe differing grains or cryſtals appear for the moſt part more exquiſitely figured, than oftentimes vitriol does. From ſpirit of urine and ſpirit of nitre, when I have ſuffered them to remain long together before coagulation, and freed the mixture from the ſuperfluous moiſture very ſlowly, I have ſometimes obtained fine long cryſtals (ſome of which I can ſhew you) ſo ſhaped, that moſt beholders would take them for cryſtals of ſalt-petre. And I have likewiſe tried, that whereas ſilver is wont to ſhoot into plates exceeding thin, almoſt like thoſe of *Moſcovia* glaſs, when I have diſſolved a pretty quantity of it in aqua fortis or ſpirit of nitre, and ſuffered it to ſhoot very leiſurely, I have obtained lunar cryſtals, (ſeveral of which I have yet by me,) whoſe figure, though ſo pretty as to have given ſome wonder even to an excellent geometrician, is differing enough from that of the thin plates formerly mentioned; each cryſtal being compoſed of many ſmall and finely ſhaped ſolids, that ſtick ſo congruouſly to one another, as to have one ſurface, that appeared plain enough, common to them all.

THIRDLY, That inſenſible corpuſcles of different, but all of them exquiſite ſhapes, and endowed with plain, as well as ſmooth ſides, will conſtitute bodies variouſly, but all very finely figured; I have made uſe of ſeveral ways to manifeſt. And firſt, though harts-horn, blood, and urine, being reſolved, and (as the chymiſts ſpeak) analyzed by diſtillation, may well be ſuppoſed to have their ſubſtantial forms (if they had any) deſtroyed by the action of the fire; yet in regard the ſaline particles they contain, are endowed with ſuch figures as we have been ſpeaking of, when in the liquor, that abounds with either of theſe volatile ſalts, the diſſolved particles do leiſurely ſhoot into cryſtals, I have divers times obſerved in theſe many maſſes, (ſome bigger and ſome leſs,) whoſe ſurfaces had plains, ſome of figures, as to ſenſe, exactly geometrical, and others very curious and pleaſant. And of theſe finely ſhaped cryſtals of various ſizes, I have pretty ſtore by me. And becauſe, (as it may be probably gathered from the event) the ſaline corpuſcles of ſtillatitious acid liquors, and thoſe of many of the bodies they are fitted to diſſolve, have ſuch kind of figures as we have been ſpeaking of, when the ſolutions of theſe bodies, upon the receſs of the ſuperfluous moiſture, ſhoot into cryſtals; theſe, though they will ſome times be differing enough, according to the particular natures of the diſſolved bodies, and the menſtruum, yet either the cryſtals themſelves, or their ſurfaces, or both, will oftentimes have fine and exquiſite figures; as I have tried by a menſtruum, wherewith I was able to diſſolve ſome gems, as alſo with a ſolution of coral made with ſpirit of verdigreaſe, to omit other examples. And for the ſame reaſon, when I tried, whether the particles of ſilver, diſſolved in aqua fortis, would not, without coagulating with the ſalts, convene, upon the account of their own ſhapes, into little concretions of ſmooth and flat ſurfaces, I found, that having (to afford the metalline corpuſcles ſcope to move in) diluted one part of the ſolution with a great many parts of diſtilled rain-water, (for common water will often-times make ſuch ſolutions become white or turbid,) a plate of copper being ſuſpended in the liquor, and ſuffered to lie quiet there a while, (for it need not be long) there would ſettle all about it ſwarms of little metalline and undiaphanous bodies, ſhining in the water like the ſcales of ſmall fiſhes, but formed into little plates extremely thin, with ſurfaces not only flat, but exceeding gloſſy: and among thoſe, divers of the larger were prettily figured at the edges. And as for gold, its corpuſcles are ſufficiently diſpoſed to convene with thoſe of fit or congruous ſalts into concretions of determinate ſhapes, as I have found in the cryſtals I obtained from gold diſſolved in aqua regis, and after having been ſuffered to loſe its ſuperfluous moiſture, kept in a cold place; and not only ſo, but alſo when, by a more powerful menſtruum, I had ſubdivided the body of gold into ſuch minute particles, that they were ſublimable, (for that I can aſſure you is poſſible;) theſe volatile particles of gold, with the ſalts, wherewith they were elevated, afforded me (ſometimes) ſtore of cryſtals, which, though not all of them near of the ſame bigneſs, reſembled one another in their ſhape, which was regular enough, and a very pretty one. But of this more elſewhere.

§ I REMEMBER I have alſo long ſince taken pleaſure to diſſolve two or more of thoſe ſaline bodies, whoſe ſhapes we know already, in fair water, that by a very gentle evaporation I might obtain concretions whoſe ſhapes ſhould be, though curious, yet differing from the figure of either of the ingredients. But we muſt not expect, that in all caſes the ſalts diſſolved together ſhould be totally compounded: for oftentimes they are of ſuch different natures, that one will ſhoot much ſooner than another, and then it frequently happens, that a good proportion of that will be firſt cryſtallized in its own ſhape; as is conſpicuouſly to be obſerved in the refining of that impure petre, (which from the country, that affords it, the purifiers call *Barbary* nitre,) from the common ſalt it abounds with: and (alſo) as *Agricola* obſerves *, that in ſome caſes, where a vitriolate matter is mingled with that, which yields allom, thoſe two kinds of ſalts will ſhoot ſeparately in the ſame large veſſel; (which the trials I have made with the compounded ſolutions of thoſe two ſalts do not diſcountenance.) Now in ſuch caſes all, that can be expected, or needs be deſired, is, that the remaining part of the mixture, or ſome portion of it, afford cryſtals or grains of compounded ſolid figures. Though the Venetian borax, wont to be ſold in ſhops, be known to be a factitious

* *G. Agricola de Re Metallica*, lib. 12.

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tious body, compounded of ſeveral ſalts, that I ſhall not now ſtay to enumerate; and though, when we buy it, we uſually find it to conſiſt of lumps and grains miſhapen enough, yet when I diſſolved ſome of it in a good quantity of fair water, and made it coagulate very leiſurely, I had cryſtals, upon whoſe ſurfaces I could perceive very exquiſite, and, as to ſenſe, regular and geometrical figures. And one thing I muſt not here by any means pretermit, which is, that though the *caput mortuum* of common aqua fortis conſiſts of bodies of very differing natures, (for ſuch are nitre and vitriol,) and has been expoſed to a great violence of the fire; yet I have ſometimes admired the curiouſneſs of thoſe figures, that might be obtained barely by frequent ſolutions and coagulations of the ſaline particles of this *caput mortuum* in fair water. But becauſe the glaſſes, wherein my concretions were made, were too little to afford great cryſtals, and they ought to ſhoot very ſlowly; I choſe rather to ſhew the curious ſome large cryſtals, which I took out of the laboratory of an ingenious perſon, who, without minding the figures, had upon my recommendation made great quantity of that ſalt in large veſſels for a medicine; (it being the *Panacea duplicata*, ſo famous in *Holſtein.*) For divers of theſe cryſtals have not only triangles, hexagons, and rhomboides, and other figures exquiſitely cut on their ſmooth and ſpecular ſurfaces, and others, bodies of priſmatical ſhapes: but ſome of them are no leſs accurately figured than the fineſt nitre or vitriol I remember myſelf to have obſerved, and ſome alſo terminate in bodies almoſt like pyramids, conſiſting of divers triangles, that meet in one vertical point, and are no leſs admirably ſhaped, than the fairer ſort of Corniſh diamonds, that have been brought me for rarities. Beſides the producing of ſalts of new ſhapes by compounding of ſaline bodies, I have found it to be practicable not only in ſome groſs, or, as they ſpeak, corporal ſalts, ſuch as ſea-ſalt, ſalt-petre, but alſo in ſome natural and ſome chymical ſalts diſſolved together, and which perhaps you will think more conſiderable in ſaline ſpirits made by diſtillation: not that all of them are fit for this purpoſe, but that I have found divers of thoſe, that work upon one another with ebullition, to be ſo. For in that conflict the ſaline corpuſcles come to be aſſociated to one another, and thereby, or by their newly acquired figure, whilſt their coalition laſts, to loſe much of their former volatility: ſo that upon evaporation of the ſuperfluous liquor, they will not fly as otherwiſe they might, but concoagulate into finely ſhaped cryſtals, as I have tried, among other ſaline liquors, with ſpirit of urine, and ſpitit of nitre, and with oil of vitriol, and ſpirit of fermented urine, with ſpirit of ſheep's blood, and ſpirit of ſalt, and alſo with the ſpirits of ſalt and urine; which laſt experiment I the rather mention, becauſe it ſhews, by the difference of the cryſtals, afforded by thoſe two liquors from the cryſtals reſulting from one of them, namely, the ſpirit of urine, (or, if you pleaſe, the volatile ſalt wherewith it abounds,) concoagulated with a fit doſe of oil of vitriol, how much thoſe compounded emergent figures depend upon the more ſimple figures of the ſaline corpuſcles, that happen to convene into thoſe new concretes. For the ſpirit of urine, ſatiated with ſpirit of ſalt, and both very gently, and not too far evaporated, often afforded me cryſtals, that differed exceedingly in ſhape from thoſe, which I obtained from the ſame ſpirit of urine, ſatiated either with oil of vitriol, or with ſpirit of nitre. For, (to add that upon the by,) that ſalt, compounded of the two ſpirits of urine and of common ſalt, is wont to be very prettily figured, conſiſting of one long beam as it were, whence on both ſides iſſue out far ſhorter cryſtals, ſometimes perpendicular to that, and parallel to one another like the teeth in a comb, and ſometimes ſo inclining as to make the whole appear almoſt like a feather; which is the more remarkable, becauſe I have (many years ago) obſerved, that common ſal-armoniack, that is made of urine and common ſalt, both crude, with a proportion of ſoot, will, if warily diſſolved and coagulated, ſhoot into cryſtals of the like ſhape. How far the unknown figure of a ſalt may poſſibly (for I fear it will not eaſily) be gueſſed at by that of the figure, which it makes with ſome other ſalt, whoſe figure is already known, I leave to geometricians to conſider; having, I fear, inſiſted too long on this ſubject already. But yet I muſt add one particular more, which will as well illuſtrate and confirm much of what has been ſaid above touching the origination of vitriol, as ſhew, that the ſhape of vitriol depends upon the texture of the bodies whereof it is compoed.

FOURTHLY, then, when I conſidered, that (as I formerly noted) vitriol being but a magiſtery, made by the concoagulation of the corpuſcles of a diſſolved metal with thoſe of the menſtruum, the magiſteries of other metals might, without inconvenience, be added, as other vitriolate concretes, to the green, the blue, and white vitriol, that are without ſcruple referred to the ſame ſpecies: and when I conſidered, that oil of vitriol was not a fit menſtruum to diſſolve divers of the metals, nor even all thoſe, that it will corrode, and that the like unfitneſs alſo is to be found in common ſpirit of ſalt; I pitched upon aqua fortis, or ſpirit of nitre, as that menſtruum, which was likelieſt to afford variety of vitriols. And accordingly I found, that beſides the lovely vitriol of copper formerly mentioned, that liquor would with quickſilver afford one ſort of cryſtals, with ſilver another, and with lead a third; all which cryſtals of vitriol, as they differed from each other in other qualities, (upon which ſcore you will find this experiment elſewhere mentioned,) ſo they did very manifeſtly and conſiderably differ in ſhape; the cryſtals of ſilver ſhooting in exceeding thin plates, and thoſe of lead and quickſilver obtaining

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taining figures, though differing enough from each other, yet of a far greater depth and thickneſs, and leſs remote from the figure of common vitriol or ſea-ſalt: and yet all theſe vitriols, eſpecially that of crude lead, when it was happily made, had ſhapes curious and elaborate, as well as thoſe we admire in common vitriol or ſea-ſalt.

IF then theſe curious ſhapes, which are believed to be of the admirableſt effects, and of the ſtrongeſt proofs of ſubſtantial forms, may be the reſults of texture; and if art can produce vitriol itſelf as well as nature, why may we not think, that in ordinary phænomena, that have much leſs of wonder, recourſe is wont to be had to ſubſtantial forms without any neceſſity? (matter, and a convention of accidents being able to ſerve the turn without them;) and why ſhould we wilfully exclude thoſe productions of the fire, wherein the chymiſt is but a ſervant of nature, from the number of natural bodies? And indeed, ſince there is no certain diagnoſtick agreed on, whereby to diſcriminate natural and factitious bodies, and conſtitute the ſpecies of both; I ſee not, why we may not draw arguments from the qualities and operations of ſeveral of thoſe, that are called factitious, to ſhew how much may be aſcribed to, and performed by the mechanical characterization, or ſtamp of matter; of which we have a noble inſtance in gun-powder, wherein, by a bare comminution and blending the ingredients, nitre, charcoal, and brimſtone, which have only a new, and that an exceeding ſlight contexture, each retaining its own nature, in the mixture, ſo that there is no colour afforded to the pretence of a ſubſtantial form; there is produced a new body, whoſe operations are more powerful and prodigious than thoſe of almoſt any body of nature's own compounding. And though glaſs be but an artificial concrete, yet, beſides that it is a very noble and uſeful one, nature herſelf has produced very few, if enough to make up a number more laſting and more unalterable. And indeed divers of thoſe factitious bodies, that chymiſtry is able to afford us, are endowed with more various and more noble qualities than many of thoſe, that are unqueſtionably natural. And if we admit theſe productions into the number of natural bodies, they will afford us a multitude of inſtances, to ſhew, that bodies may acquire many and noble qualities, barely by having mechanical affections introduced by outward agents into the matter, or deſtroyed there. As, though glaſs be ſuch a noble body, as we have lately taken notice of, yet ſince its fuſibility, tranſparency, and brittleneſs, that are its only conſtituent attributes, we can in leſs than an hour (or perhaps half that time,) turn an opacous body into tranſparent glaſs, without the addition of any other viſible body, by a change of texture made in the ſame matter, and by another change of texture, made without addition, as formerly, we can in a trice reduce glaſs into, or obtain from it, a body not glaſſy, but opacous, and otherwiſe of a very differing nature, as it had been before. And here let me add what may not a little conduce to our preſent deſign, that even thoſe, that embrace *Ariſtotle*'s principles, do unawares confeſs, that a ſlight change of texture, without the introduction of a ſubſtantial form, may not only make a ſpecifical difference betwixt bodies, but ſo vaſt a one, that they ſhall have differing genius's, and may (as the chymiſts ſpeak) belong to different kingdoms. For coral, to paſs by all other plants of that kind, that may be mentioned to the ſame purpoſe, whilſt it grows in the bottom of the ſea, is a real plant, and ſeveral times (which ſuffices for my preſent ſcope) hath been there found by an acquaintance of mine, as well as by other enquirers, ſoft and tender like another plant: nay, I elſewhere * bring very good and recent authority to prove, that it is oftentimes found very ſucculent, and does propagate its ſpecies as well as other ſhrubs; and yet coral, being gathered and removed into the air by the receſs of its ſoul, no new lapidifick form being ſo much as pretended to, turns into a concretion, that is by many eminent writers and others reckoned among lapideous ones: as indeed coral does not burn like wood, nor obey diſtillation like it; and not only its calx is very differing from the aſhes of vegetables, and is totally ſoluble in divers acid liquors, and even ſpirit of vinegar, but the uncalcined coral itſelf will be eaſily corroded by good vinegar, after the ſame manner as I have ſeen *lapis ſtellaris*, and other unqueſtionably mineral ſtones diſſolved, ſome by that liquor, and ſome by the ſpirit of it. A much ſtranger thing may be ſeen in the Eaſt-India iſland of *Sombrero*, not very far from *Sumatra*, if we may believe our countryman Sir *James Lancaſter*, who relates it as an eye-witneſs, for which reaſon, and for the ſtrangeneſs of the thing, I ſhall add the ſtory in his own words. *Here* († ſays he, ſpeaking of the coaſt of *Sombrero*) *we found upon the ſand, by the ſea-ſide, a ſmall twig growing up to a young tree; and offering to pluck up the ſame, it ſhrunk down into the ground, and ſinketh, unleſs you hold very hard. And being plucked up, a great worm is the root of it: and look how the tree groweth in greatneſs, the worm diminiſheth. Now as ſoon as the worm is wholly turned into the tree, it rooteth in the ground, and ſo groweth to be great. This transformation was one of the greateſt wonders I ſaw in all my travels. This tree being plucked up a little, the leaves ſtripped off, and the peel, by that time it was dry, turned into a hard ſtone, much like to white coral. So that* (concludes he) *this worm was twice transformed into different natures: of theſe we gathered, and brought home many.* The induſtrious *Piſo*, in his excellent hiſtory of *Braſil*, vouches a multitude of witneſſes (not having opportunity to

* In the Eſſays about things ſuppoſed to be ſpontaneouſly generated.

† *Purchas. Pilgr.* Part the firſt, p. 152.

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to be one himſelf) for the ordinary transformation of a ſort of animals (not much unlike graſhoppers) into vegetables, at a certain ſeaſon of the * year.

BUT ſince I ſet down this relation of Sir *John Lancaſter*, I have met with another, whoſe ſtrangeneſs may much countenance it, in a ſmall tract newly publiſhed by a Jeſuit, *F. Michael Boym*, whom a good critick much commended to me. For this author doth, as an eye-witneſs, affirm, that which is little leſs to my preſent purpoſe: † *Je vis, &c.* i. e. *I ſaw in a ſmall freſh-water and ſhallow lake of the iſland* Hainan (which belongs to *China*) *crabs or craw-fiſhes, which, as ſoon as they were drawn out of the water, did in a moment loſe both life and motion, and became petrified, though nothing appeared to be changed either in the external or internal figure of their bodies.* What he further adds of theſe fiſhes, is but of their virtues in phyſick, which not concerning our ſubject, I ſhall, *Pyrophilus*, willingly pretermit it; and even, as to our countryman's relation, hoping, by means of an ingenious correſpondent in the *Eaſt Indies*, to receive a further information about the ſtrange plant he mentions, I ſhall at preſent urge only what has been taken notice of concerning coral, to countenance the obſervation, for whoſe ſake theſe narratives have been alledged. And ſo likewiſe as to what I was ſaying of glaſs and gunpowder, our receiving of thoſe, and the generality of factitious bodies, into the catalogue of natural bodies, is not (which I formerly alſo intimated) neceſſary to my preſent argument: whereto it is ſufficient, that vitriol is granted on all hands to be a natural body, though it be alſo producible by art. And alſo to the argument it affords us, we might add that memorable experiment delivered by *Helmont*, of turning oil of vitriol into allom, by the odour (as he calls it) of mercury, if, however it be not deſpicable, we had found it fit to be relied on. But reſerving an account of that for another place, we ſhall ſubſtitute the inſtance preſented us by our author, about the production of ſalt-petre: for if, having diſſolved pot-aſhes in fair water, you coagulate the filtrated ſolution into a white ſalt, and on that pour ſpirit of nitre, till they will not hiſs any longer; there will ſhoot, when the ſuperfluous water is evaporated, cryſtals, that proclaim their nitrous nature by their priſmatical (or at leaſt priſm-like) ſhape, their eaſy fuſion, their accenſion, and deflagration, and other qualities, partly mentioned by our author, and partly diſcoverable by a little curioſity in making trials.

II. EXPERIMENTAL ATTEMPTS *about the* REDINTEGRATION *of* BODIES.

THE former of thoſe two arguments, *Pyrophilus*, by which I propoſed to confirm the origin of forms, was, as you may remember, grounded upon the manner, by which ſuch a convention of accidents, as deſerves to paſs for a form, may be produced: and that having been hitherto proſecuted, it now remains, that we proceed to the ſecond argument, drawn not (as the former) from the firſt production, but from the reproduction of a phyſical body. And though both theſe arguments are valid, yet if this latter could, in ſpite of the difficulties intervening in making of the experiments, that belong to it, be as clearly made out as the former, you would, I ſuppoſe, like it much the better of the two. For if we could reproduce a body, which has been deprived of its ſubſtantial form, you would, I preſume, think it highly probable, if not more than probable, that (to borrow our author's expreſſion) that, which is commonly called the form of a concrete, which gives it its being and denomination, and from whence all its qualities are in the vulgar philoſophy, by I know not what inexplicable ways, ſuppoſed to flow, may be in ſome bodies but a characterization or modification of the matter they conſiſt of; whoſe parts, by being ſo and ſo diſpoſed in relation to each other, conſtitute ſuch a determinate kind of body, endowed with ſuch and ſuch properties: whereas if the ſame parts were otherwiſe diſpoſed, they would conſtitute other bodies, of very differing natures from that of the concrete, whoſe parts they formerly were, and which may again reſult or be produced after its diſſipation, and ſeeming deſtruction, by the reunion of the ſame component particles, aſſociated according to their former diſpoſition.

BUT though it were not impoſſible to make an adequate redintegration of a chymically analyzed body, becauſe ſome of the diſſipated parts will either eſcape through the junctures of the veſſels, (though diligently cloſed) or, if they be very ſubtile, will fly away upon the disjoining of the veſſels, or will irrecoverably ſtick to the inſide of them: yet I ſee not why ſuch a reproduction, as is very poſſible to be effected, may not ſuffice to manifeſt what we intend to make out by it. For even in ſuch experiments it appears, that when the form of a natural body is aboliſhed,

* The paſſage, which is long, I do not here tranſcribe, having had occaſion to do it elſewhere. It is extant, *lib. 5. cap. 21.* and at the cloſe of his narrative he ſubjoins, *Non eſt, quod quiſquam de veritate dubitet, cùm infinitas teſtes habeat Braſilia, &c.*

† *Flora Sinenſis, ou Traite des Fleurs, &c.* under the Title *Lozmeoques.*

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liſhed, and its parts violently ſcattered, by the bare re-union of ſome parts after the former manner, the very ſame matter the deſtroyed was before made of, may, without addition of other bodies, be brought again to conſtitute a body of the like nature with the former, though not of equal bulk. And indeed the experiment recorded by our author about the reproduction of ſalt-petre, as it is the beſt and ſucceſsfulleſt I have ever been able to make upon bodies, that require a ſtrong heat to diſſipate them; ſo I hope it will ſuffice to give you thoſe thoughts about this matter, that the author deſigned in alledging it; and therefore, though having premiſed thus much, I ſhall proceed to acquaint you with the ſucceſs of ſome attempts he intimates (in that eſſay) his intention of making for the redintegration of ſome bodies; yet doing it out of ſome hiſtorical notes, I find among my looſe papers, that, which I at preſent pretend to, is but partly to ſhew you the difficulty of ſuch attempts, which, ſince our author's eſſay was communicated, have been repreſented (I fear, by conjecture only) as very eaſy to be accurately enough done; and partly becauſe our author does not, without reaſon, intimate the uſefulneſs of redintegrations, in caſe they can be effected; and does not cauſeleſly intimate, that ſuch attempts, though they ſhould not perfectly ſucceed, may increaſe the number of noble and active bodies, and conſequently the inventory of mankind's goods.

UPON ſuch conſiderations we attempted the diſſipation and re-union of the parts of common amber; and though chymiſts, for fear of breaking their veſſels, are wont, when they commit it to diſtillation, to add to it a *caput mortuum* (as they ſpeak) of ſand, brick, *&c.* (in whoſe room we ſometimes chuſe to ſubſtitute beaten glaſs;) which hinders them to judge of and employ the remanence of the amber, after the diſtillation is finiſhed; yet we ſuppoſed, and found, that if the retort were not too much filled, and if the fire were ſlowly and warily enough adminiſtred, the addition of any other body would be needleſs. Wherefore, having put into a glaſs retort four or five ounces of amber, and adminiſtred a gentle and gradual heat, we obſerved the amber to melt and bubble, (which we therefore mention, becauſe ingenious men have lately queſtioned, whether it can be melted,) and having ended the operation, and ſever'd the veſſels, we found, that there was come over in the form, partly of oil, partly of ſpirit and phlegm, and partly of volatile ſalt, near half the weight of the concrete: and having broken the retort, we found in the bottom of it a cake of coal-black matter, than whoſe upper ſurface I ſcarce remember to have ſeen in my whole life any thing more exquiſitely poliſhed; inſomuch, that, notwithſtanding the colour, as long as I kept it, it was fit to ſerve for a looking-glaſs: and this ſmooth maſs being broken, (for it was exceeding brittle,) the larger fragments of it appeared adorned with an excellent luſtre. All thoſe parts of the amber, being put together into a glaſs body, with a blind head luted to it, were placed in ſand, to be incorporated by a gentle heat: but whilſt I ſtept aſide to receive a viſit, the fire having been increaſed without my knowledge, the fumes aſcended ſo copiouſly, that they lifted up the veſſel out of the ſand, whereupon falling againſt the ſide of the furnace, it broke at the top, but being ſeaſonably called, we ſaved all but the fumes; and the remaining matter looks not unlike tar, and with the leaſt heat may be poured out like a liquor, ſticking, even when it is cold, to the fingers. Yet this opened body doth not eaſily communicate ſo much as a tincture to ſpirit of wine, which therefore ſeems ſomewhat ſtrange, becauſe another time preſuming, that this would be a good way to obtain a ſolution of ſome of the reſinous parts of amber, we did by pouring ſpirit of wine, that (though rectified) was not of the very beſt, upon the re-united parts of amber, lightly digeſted into a maſs, eaſily obtain a clear yellow ſolution, very differing from the tincture of amber, and abounding (as I found by trial) in the diſſolved ſubſtance of the amber: but in oil of turpentine we have, in a ſhort time, diſſolved it into a blood-red balſam, which may be of good uſe (at leaſt) to chirurgeons. And having again made the former experiment with more warineſs than before, we had the like ſucceſs in our diſtillation, but the re-united parts of the amber being ſet to digeſt in a large bolt-head, the liquor, that was drawn off, did in a few hours, from its own *caput mortuum*, extract a blood-red tincture, or elſe made a ſolution of ſome part of it; whereby it obtained a very deep red; but having been, by intervening accidents, hindered from finiſhing the experiment, we miſſed the ſatisfaction of knowing to what it may be brought at laſt.

AND as for what our author tells us of this deſign to attempt the redintegration of vitriol, turpentine, and ſome other concretes, wherein it ſeemed not unpracticable, he found in it more difficulty than every one would expect. For the bodies, on which ſuch experiments are likelieſt to ſucceed, ſeem to be allum, ſea-ſalt, and vitriol. And as for allum, he found it a troubleſome work to take (as a Spagyriſt would ſpeak) the principles of it aſunder, in regard, that it is inconvenient to diſtil it with a *caput mortuum*, (as chymiſts call any fixed additament) leſt that ſhould hinder the deſired redintegration of the diſſipated parts. And when he diſtilled it by itſelf, without any ſuch additament, he found, that with a moderate heat the allum would ſcarce part with any thing but its phlegm; and if he urged it with a ſtrong fire, he found it would ſo ſwell, as to endanger the breaking of the retort, or threaten the boiling over into the receiver. (Yet having once been able very warily to abſtract as much phlegm and ſpirit, as I conveniently could, from a parcel of roch-allum, and having poured it back upon that pulverized *caput mortuum*, and left the veſſel long in a

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quiet place, I found, that the corpuſcles of the liquor, having had time, after a multitude of occurſions, to accommodate and reunite themſelves to the more fixed parts of the concrete, did, by that aſſociation (or diſſolution) recompoſe, at the top of the powder, many cryſtalline grains of finely figured ſalt, which increaſing with time, made me hope, that, at the length, the whole or the greateſt part would be reduced into alum, which yet a miſchance, that robbed me of the glaſs, hindered me to ſee. So likewiſe of ſea-ſalt, if it be diſtilled, as it is uſual, with thrice its weight of burned clay, or beaten brick, it will prove inconvenient in reference to its redintegration: and if it be diſtilled alone, it is apt to be fluxed by the heat of the fire, and whilſt it remains in fuſion, will ſcarce yield any ſpirit at all. And as for vitriol, though the redintegration of it might ſeem to be leſs hopeful than that of the other ſalts, in regard that it conſiſts, not only of a ſaline, but of a metalline body, whence it may be ſuppoſed to be of a more intricate and elaborate texture; yet becauſe there needs no *caput mortuum* in the diſtillation of it, we did, to purſue our author's intimated deſigns, make two or three attempts upon it, and ſeemed to miſs of our aim, rather upon the account of accidental hindrances, than of any inſuperable difficulty in the thing itſelf. For once we, with a ſtrong fire, drew off from a parcel of common blue vitriol the phlegm and ſpirit, and ſome quantity of the heavy oil, (as chymiſts abuſively call it:) theſe liquors, as they came over without ſeparation, we divided into ſeveral parts, and the remaining very red *caput mortuum* into as many. One of theſe parcels of liquor we poured over night upon its correſpondent portion of the newly mentioned red powder. But having left it in a window, and the night proving very bitter, in the morning I found the glaſs cracked in many places, by the violence of the froſt, and the liquor ſeemed to have been ſoaked up by the powder, and to have very much ſwelled it. This mixture then I took out, and placing it in an open-mouthed glaſs in a window, I found, after a while, divers grains of pure vitriol upon the other matter, and ſome little ſwellings, not unlike thoſe we ſhall preſently have occaſion to ſpeak of. I took likewiſe a much larger parcel of the forementioned liquor, and its correſpondent proportion of *caput mortuum*; and having leiſurely mixed them in a large glaſs baſon, I obtained divers phænomena, that belong not to this place, but may be met with where they will more properly fall in. In this baſon (which I laid in the window, and kept from agitation,) I perceived, after a while, the liquor to acquire a bluiſh tincture, and after ten or twelve weeks, I found the mixture dry, (for it ſeems it was too much expoſed to the air;) but the ſurface of it adorned in divers places with grains of vitriol very curiouſly figured.

AND beſides theſe, there were ſtore of protuberances, which conſiſted of abundance of ſmall vitriolate particles, which ſeemed in the way to a coalition; for having let the baſon alone for four or five months longer, the matter appeared cruſted over, partly with very elevated ſaline protuberances, partly with leſſer parcels, and partly alſo with conſiderable broad cakes of vitriol, ſome of above half an inch in breadth, and proportionabdly long: and indeed the whole ſurface was ſo oddly diverſified, that I cannot count the trouble theſe trials have put me to, miſpent. Another time, in a more ſlender and narrow-mouthed glaſs, I poured back upon the *caput mortuum* of vitriol the liquors, I had by violence of the fire forced from it; ſo that the liquid part did ſwim a pretty height above the red calx, and remained a while limpid and colourleſs: but the veſſel having ſtood for ſome time unſtopped in a window, the liquor after a while acquired by degrees a very deep vitriolate colour, and not long after there appeared, at the bottom, and on the top of the calx, many fair and exquiſitely figured grains of vitriol, which covered the ſurface of the calx, and the longer the veſſel continued in the window, the deeper did this change, made upon the upper part of the powder, ſeem to penetrate: ſo that I began to hope, that, in proceſs of time, almoſt (if not more than almoſt) the whole mixture would be reduced to perfect vitriol. But an accident robbed me of my glaſs, before I could ſee the utmoſt of the event.

And, on this occaſion, I muſt not pretermit an odd experiment I lately made, though I dare not undertake to make it again. I elſewhere relate, how I digeſted, for divers weeks, a quantity of powdered antimony, with a greater weight by half of oil of vitriol; and how having at length committed this mixture to diſtillation, and thereby obtained, beſides a little liquor, a pretty quantity of combuſtible antimonial, or antimonio-vitriolate ſulphur; there remained, in the bottom of the retort, a ſomewhat light and very friable *caput mortuum*, all the upper part of which was at leaſt as white as common wood-aſhes, and the reſt looked like a cinder. And now I muſt tell you, what became of this *caput mortuum*, whereof I there make no further mention. We could not well foreſee what could be made of it, but very probable it was, that it would afford us ſome new diſcovery, by being expoſed to the fire, in regard of the copious ſulphur, whereof it ſeemed to have been deprived; provided it were urged in cloſe veſſels, where nothing could be loſt. Whereupon committing it to a naked fire in a ſmall glaſs retort, well coated and accommodated with a receiver, we kept it there many hours, and at length ſevering the veſſels, we found (which need not be wondered at) no antimonial quickſilver, and much leſs of ſulphur ſublimed than we expected: wherefore greedily haſtening to the *caput mortuum*, we found it fluxed into a maſs, covered with a thin cake of glaſs, whoſe fragments being held againſt the light, were not all coloured, as antimonial glaſs is wont to be, but were as colourleſs as common white glaſs.

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glaſs. The lump above mentioned being broken, was found, ſomewhat to our wonder, to be perfect black antimony, adorned with long ſhining ſtreaks, as common antimony is wont to be: only this antimony ſeemed to have been a little refined by the ſequeſtration of its unneceſſary ſulphur; which ingredient ſeems by this experiment, as well as by ſome other obſervations of ours, to be more copious in ſome particular parcels of that mineral, than is abſolutely requiſite to the conſtitution of antimony. Though in our caſe it may be ſuſpected, that the reduction of part of the maſs to a colourleſs glaſs was an effect of the abſence of ſo much of the ſulphur, and might in part make the remaining maſs ſome amends for it. What we further did with this new or reproduced concrete, is not proper to be here told you: only for your ſatisfaction we have kept a lump of it, that you may with us take notice of what ſome philoſophers would call the mindfulneſs of nature; which, when a body was deprived of a not inconſiderable portion of its chief ingredient, and had all its other parts diſſipated and ſhuffled, and diſcoloured, ſo as not to be knowable, was able to rally thoſe ſcattered and diſguiſed parts, and marſhal or diſpoſe them into a body of the former conſiſtence, colour, *&c.* though (which is not here to be overlooked) the contexture of antimony, by reaſon of the copious ſhining *ſtriæ*, that enoble the darker body, be much more elaborate, and therefore more uneaſy to be reſtored, than that of many other concretes.

BUT among all my trials about the redintegration of bodies, that, which ſeemed to ſucceed beſt, was made upon turpentine: for having taken ſome ounces of this, very pure and good, and put it into a glaſs retort, I diſtilled ſo long with a very gentle fire, till I had ſeparated it into a good quantity of very clear liquor, and a *caput mortuum* very dry and brittle; then breaking the retort, I powdered the *caput mortuum*, which, when it was taken out, was exceeding ſleek, and tranſparent enough, and very red, but being powdered, appeared of a pure yellow colour. This powder I carefully mixed with the liquor, that had been diſtilled from it, which immediately diſſolved part of it into a deep red balſam; but by further digeſtion, in a large glaſs exquiſitely ſtopt, that colour began to grow fainter, though the remaining part of the powder, (except a very little, proportionable to ſo much of the liquor, as may be ſuppoſed to have been waſted by evaporation and transfuſion out of one veſſel into another,) be perfectly diſſolved, and ſo well reunited to the more fugitive parts of the concrete, that there is ſcarce any, that by the ſmell, or taſte, or conſiſtence, would take it for other than good and laudable turpentine.

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CONSIDERATIONS AND EXPERIMENTS, TOUCHING THE Origin of QUALITIES and FORMS.

THE HISTORICAL PART.

SECTION I.

Containing the obſervations.

IN the foregoing notes I have endeavoured with as much clearneſs as the difficulty of the ſubject and the brevity I was confined to permitted, to give a ſcheme or ſummary of the principles of the corpuſcularian philoſophy, as I apprehended them, by way of a ſhort introduction to it, at leaſt as far as I judged neceſſary for the better underſtanding of what is contained in our notes and experiments, concerning the productions and changes of particular qualities. But though, I hope, I have not ſo affected brevity as to fall into obſcurity, yet ſince theſe principles are built upon the phænomena of nature, and deviſed in order to the explication of them, I know not what I can do more proper to recommend them, than to ſubjoin ſome ſuch natural phænomena, as either induce me to take up ſuch notions, or which I was directed to find out by the notions I had embraced. And ſince I appeal to the teſtimony of nature to verify the doctrine I have been propoſing about the origin and production of qualities, (for that of forms will require a diſtinct diſcourſe;) I think it very proper to ſet down ſome obſervations of what nature does, without being over-ruled by the power and ſkill of man, as well as ſome experiments, wherein nature is guided, and as it were maſtered by art, that ſo ſhe may be made to atteſt the truth of our doctrine, as well when ſhe diſcloſes her ſelf freely, and, if I may ſo ſpeak, of her own accord, as when ſhe is as it were cited to make her depoſitions by the induſtry of man. The obſervations will be but the more ſuitable to our deſign for being common and familiar as to the phænomena, though perhaps new enough as to the application to our purpoſe. And as for the experiments, becauſe thoſe, that belong more immediately to this or that particular quality, may be met with in the notes, that treat of it, I thought it not amiſs, that the experiments ſhould be both few in number, and yet ſo pregnant, that every one of them ſhould afford ſuch differing phænomena, as may make it applicable to more than one quality.

I.

THE obſervation I will begin with ſhall be fetched from what happens in the hatching of an egg. For as familiar and obvious a thing as it is, (eſpecially after what the learned *Fabricus ab Aquapendente*, and a recenter anatomiſt have delivered about them,) that there is a great change made in the ſubſtance of the egg, when it is by incubation turned into a chick; yet, as far as I know, this change hath not been taken notice of for the ſame purpoſe, to which I am about to apply it.

I CONSIDER then, that in a prolific egg (for inſtance, that of a hen,) as well the liquor of the yolk, as that of the white is a ſubſtance, as to ſenſe, ſimilar. For upon the ſame account, that anatomiſts and phyſicians call ſeveral parts of the human body, as bones, membranes, *&c.* ſimilar, that is ſuch, as that every ſenſible part of it hath the ſame nature or denomination with the whole, as every ſplinter of bone is bone, as every ſhred of ſkin is ſkin.

AND though I find by diſtilling the yolks and whites they ſeem to be diſſimilar bodies, in regard that the white of an egg (for example) will afford ſubſtances of a very differing nature, as phlegm, ſalt, oil, and earth; yet (not now to examine, whether, or how far theſe may be eſteemed productions of the fire, that are rather obtained from the white of the egg, than were præ-exiſtent in it; not to mention this, I ſay,) it doth not appear by diſtillation, that the white of an egg is other than a ſimilar body in the ſenſe above delivered. For it would be hard to prove, that one part of the white of an egg will not be made to yield the ſame differing ſubſtances by diſtillation, that any other part does; and bones themſelves, and other hard parts of a human body, that are confeſſedly ſimilar, may by diſtillation be made to afford ſalt, and phlegm, and ſpirit, and oil, and earth, as well as the white of an egg.

THIS being thus ſettled in the firſt place, we may in the next conſider, that by beating the white of an egg well with a whiſk, you may reduce it from a ſomewhat tenacious, into a fluid body, though this production of a liquor be, as we elſewhere noted, effected by a divulſion, agitation, *&c.* of the parts; that is, in a word, by a mechanical change of the texture of the body.

IN the third place I conſider, that, according to the exacteſt obſervations of modern anatomiſts, which our own obſervations do not contradict, the rudiments of the chick, lodged in

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in the cicatricula or white ſpeck upon the coat of the yolk, is nouriſhed, till it have obtained to be a great chick, only by the white of the egg; the yolk being by the providence of nature reſerved as a more ſtrong and ſolid aliment, till the chick have abſumed the white, and be thereby grown great and ſtrong enough to digeſt the yolk: and in effect you may ſee the chick furniſhed not only with all the neceſſary, but divers other parts, as head, wings, legs, and beak, and claws, whilſt the yolk ſeems yet as it were untouched. But whether this obſervation about the entireneſs of the yolk be preciſely true, is not much material to our preſent purpoſe, nor would I be thought to build much upon it; ſince the yolk itſelf, eſpecially at that time, is wont to be fluid enough, and to be a liquor perhaps no leſs ſo than the white was, and that is enough for my preſent purpoſe.

For in the laſt place I conſider, that the nutritive liquor of an egg, which is in itſelf a body ſo very ſoft, that by a little agitation it may be made fluid, and is readily enough diſſolvable in common cold water; this very ſubſtance, I ſay, being brooded on by the hen, will within two or three weeks be tranſmuted into a chick, furniſhed with organical parts, as eyes, ears, wings, legs, *&c.* of a very differing fabrick, and with a good number of ſimilar ones, as bones, cartilages, ligaments, tendons, membranes, *&c.* which differ very much in texture from one another; beſides the liquors, as blood, chyle, gall, *&c.* contained in the ſolid parts. So that here we have out of the white of an egg, which is a ſubſtance ſimilar, inſipid, ſoft, (not to call it fluid,) diaphanous, colourleſs, and readily diſſoluble in cold water; out of this ſubſtance, I ſay, we have, by the new and various contrivement of the ſmall parts it conſiſted of, an animal, ſome of whoſe parts are not tranſparent, but opacous; ſome of them red, as the blood; ſome yellow or greeniſh, as the gall; ſome white, as the brain; ſome fluid, as the blood, and other juices; ſome conſiſtent, as the bones, fleſh, and other ſtable parts of the body; ſome ſolid and frangible, as the bones; others tough and flexible, as the ligaments; others ſoft and looſely coherent, as the marrow; ſome without ſprings, as many of the parts; ſome with ſprings, as the feathers; ſome apt to mingle readily with cold water, as the blood, the gall; ſome not to be *ſo* diſſolved in it, as the bones, the claws, and the feathers; ſome well taſted, as the fleſh and blood; ſome very ill taſted, as the gall; (for that I have purpoſely and particularly obſerved.) In a word, we have here produced out of ſuch an uniform matter as the white of an egg,

First, new kind of qualities, as (beſides opacity) colours, (whereof a ſingle feather will ſometimes afford us variety,) odours, taſtes, and heat in the heart and blood of the chick, hardneſs, ſmoothneſs, roughneſs, *&c.*

Secondly, divers other qualities, that are wont to be diſtinguiſhed from ſenſible ones, as fluidity (in the blood and aqueous humour of the eye,) conſiſtency in the griſtles, fleſh, *&c.* hardneſs, flexibility, ſpringineſs, toughneſs, unfitneſs to be diſſolved in cold water, and ſeveral others. To which may probably be added,

Thirdly, ſome occult properties, as phyſicians obſerve, that ſome birds, as young ſwallows, young magpyes afford ſpecifick or at leaſt noble medicines in the falling-ſickneſs, hyſterical fits, and divers other diſtempers.

Fourthly, I very well foreſee it may be objected, that the chick with all its parts is not a mechanically contrived engine, but faſhioned out of matter by the ſoul of the bird, lodged chiefly in the cicatricula, which by its plaſtick power faſhions the obſequious matter, and becomes the architect of its own manſion. But not here to examine, whether any animal, except man, be other than a curious engine, I anſwer, that this objection invalidates not what I intend to prove from the alledged example. For let the plaſtick principle be what it will, yet ſtill, being a phyſical agent, it muſt act after a phyſical manner; and having no other matter to work upon but the white of the egg, it can work upon that matter but as phyſical agents, and conſequently can but divide the matter into minute parts of ſeveral ſizes and ſhapes, and by local motion variouſly context them, according to the exigency of the animal to be produced, though from ſo many various textures of the produced parts there muſt naturally emerge ſuch differences of colours, taſtes, and conſiſtencies, and other qualities, as we have been taking notice of. That, which we are here to conſider, is not what is the agent or efficient in theſe productions, but what is done to the matter to effect them. And though ſome birds by an inbred ſkill do very artificially build their curious neſts, yet cannot nature, that teaches them, enable them to do any more than ſelect the materials of their neſts, and by local motion divide, tranſport, and connect them after a certain manner. And when man himſelf, who is undoubtedly an intelligent agent, is to frame a building or an engine, he may indeed, by the help of reaſon and art, contrive his materials curiouſly and ſkilfully; but ſtill all he can do, is but to move, divide, tranſpoſe, and context the ſeveral parts, into which he is able to reduce the matter aſſigned him.

Nor need we imagine, that the ſoul of that hen, which having firſt produced the egg, does after a while ſit on it, hath any peculiar efficiency in hatching of a chick: for the egg will be well hatched by another hen, though that, which laid it, be dead. And, which is more, we are aſſured by the teſtimony of very good authors, as well as of recent travellers, that in ſome places, eſpecially in *Ægypt*, there needs no bird at all to the production of a chick out of an egg, ſince they hatch multitudes of eggs by the regulated heat of ovens or dunghils. And indeed, that there is a motion or agitation of the parts of the egg by the external heat, whereby it is hatched, is evident of it ſelf, and not (as far as I know) denied by any; and that alſo the white ſubſtance is abſumed, and contexed or contrived into the body of the chick, and

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its ſeveral parts, is manifeſt to ſenſe; eſpecially if one hath the curioſity to obſerve the progreſs of the chick's formation and increment. But as it is evident, that theſe two things, the ſubſtance of the white, and the local motion, wherein the external heat neceſſary to incubation puts its parts, do eminently concur to the production of the chick, ſo that the formative power (whatever that be) doth any more than guide theſe motions, and thereby aſſociate the fitted particles of matter after the manner requiſite to conſtitute a chick, is that, which I think will not eaſily be evinced. And I might, to what I ſaid of the egg, add ſeveral things touching the generation of viviparous animals, which the learned *Fabricius ab Aquapendente*, as well as ſome of the ancient philoſophers, would have to be generated from an imperfect kind of eggs: but I take the eggs of birds to be much fitter to inſtance in, becauſe they are things, that we have more at command, and wherewith we can conveniently make more trials and obſervations; and eſpecially becauſe in perfect eggs the matter to be tranſmuted is more cloſely locked up, and being kept from any viſible ſupply of matter, confined to be wrought upon by the external heat, and by its own vital principle within.

II.

WATER being generally eſteemed an elementary body, and being at leaſt far more homogeneous than bodies here below are wont to be, it may make very much for our preſent purpoſe to ſhew, that water itſelf, that is fluid, taſteleſs, inodorous, diaphanous, colourleſs, volatile, *&c.* may, by a differing texture of its parts, be brought to conſtitute bodies of attributes very diſtant from theſe. This I thought

ht be done, by nouriſhing vegetables with ſimple water. For in caſe I could do ſo, all or the greateſt part of that, which would accrue to the vegetable thus nouriſhed would appear to have been materially but water, with what exotick quality ſoever it may afterwards, when tranſmuted, be endowed.

THE ingenious *Helmont* indeed mentions an experiment ſomewhat of this nature, though not to the ſame purpoſe, which he made by planting a branch of willow into a pot full of earth, and obſerving the increaſe of weight he obtained after divers years, though he fed the plant but with rain-water. And ſome learned modern naturaliſts have conjectured at the eaſy tranſmutableneſs of water, by what happens in gardens and orchards, where the ſame ſhowers or rain after a long drought makes a great number of differing plants to flouriſh. But though theſe things be worthy of their authors, yet I thought they would not be ſo fit for my purpoſe, becauſe it may be ſpeciouſly enough objected, that the rain-water does not make theſe plants thrive and flouriſh, by immediately affording them the aliments they aſſimilate into their own ſubſtance, but by proving a vehicle, that diſſolves the ſaline, and other alimental ſubſtances of the earth, and dilutes both them and the nutritive juice, which, in a part of the plant it ſelf, it may find too much thickned by the drought or heat of the ambient air, and by this means it contributes to the nouriſhment of the plant, though it ſelf be inſenſibly afterwards exhaled into vapours. And indeed experience ſhews us, that ſeveral plants, that thrive not well without rain-water, are not yet nouriſhed by it alone, ſince when corn in the field, and fruit-trees in orchards, have conſumed the ſaline and ſulphureous juices of the earth, they will not proſper there, how much rain ſoever falls upon the land, till the ground by dung or otherwiſe be ſupplied again with ſuch aſſimilable juices. Wherefore I rather choſe to attempt the making of plants grow in phials filled with water, not only to prevent the forementioned objection, and alſo to make the experiment leſs tedious, but that I might have the pleaſure of ſeeing the progreſs of nature in the tranſmutation of water: and my obſervations of this kind as novelties, unmentioned by any other writer, I ſhewed divers ingenious friends, who having better opportunities than I of ſtaying in one place, have attempted the like, and made ſucceſsful trials, which I ſuppoſe will not be concealed from the publick. Of my obſervations about things of this kind, I can at preſent find but few among my *Adverſaria*, but in them I find enough for my preſent turn. For they and my memory inform me, that vinca pervinca, raphanus aquaticus, ſpearmint, and even ranunculus it ſelf, did grow and proſper very well in phials filled with fair water, by whoſe necks the leaves were ſupported, and the plant kept from ſinking: ſome of theſe were only cuttings without roots, diverſe of them were left in the water all the autumn, and great part of the winter, and at the end of *January* were taken out verdant and with fair roots, which they had ſhot in the water. And beſides I find, that particularly a branch or ſprig of raphanus aquaticus was kept full nine months, and during that time withered not the whole winter, and was taken out of the water with many fibrous roots, and ſome green buds, and an increaſe of weight; and that a ſtump of ranunculus did ſo proſper in the water, that in a month's time it had attained to a pretty deal more than double the weight it had, when it was put in. And the next note, which I find concerning theſe plants, informs me, that the above mentioned crow's-foot being taken out again at ſix months after it was put in, weighed a drachm and a half wanting a grain and a half, that is, ſomewhat above thrice as much as it did at firſt. This laſt circumſtance (of the increaſe of weight) I therefore thought fit particularly to make trial of, and ſet down upon this account among others, that having doubted the roots and leaves, that ſeemed produced out of the water, might really be ſo by an oblongation and an expanſion of the plants, (as I have purpoſely tried, that an onion weighed and laid up in the ſpring, though after ſome weeks keeping in the air it ſhot blades, whereof one was five inches long, inſtead of incorporating the air or terreſtrial effluviums with itſelf, and conſequently thereby growing heavier, had loſt nine grains of its former weight;) it might by this circumſtance appear,

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that there may be a real aſſimilation and tranſmutation of water into the ſubſtance of the vegetable, as I elſewhere alſo ſhew by other proofs. For this being made out, from thence I infer, that the ſame corpuſcles, which, convening together after one manner, compoſe that fluid, inodorous, colourleſs, and inſipid body of water, being contexted after other manners, may conſtitute differing concretes, which may have firmneſs, opacity, odours, ſmells, taſtes, colours, and ſeveral other manifeſt qualities, and that too very different from one another. And beſides all this, theſe diſtinct portions of tranſmuted water may have many other qualities, without excepting thoſe, that are wont to be called ſpecific or occult; witneſs the ſeveral medicinal virtues attributed by authors to ſpearmint, and to periwinkle, to majorane, and to raphanus aquaticus. And as for ranunculus, that plant being reckoned among poiſonous ones, and among thoſe, that raiſe bliſters, it will be eaſily granted, that it hath, as other poiſons, an occult deleterial faculty: and indeed it ſomewhat deſerves our wonder, that ſo inſipid and innocent a thing as fair water, ſhould be capable of being turned into a ſubſtance of ſuch a piercing and cauſtic nature, as by contact to raiſe bliſters on a human body. And yet perhaps that is no leſs ſtrange, which we elſewhere relate, that a plant conſiſting chiefly of tranſmuted water, did by diſtillation afford us a true oil, that would not mingle with water, and conſequently was eaſily convertible into fire. But whether or no this experiment, or any ſuch like, prove, that almoſt all things may be made of all things, not immediately, but by intervention of ſucceſſive changes and diſpoſitions, is a queſtion, to which we elſewhere ſay ſomething, but are not willing in this place to ſay any thing. And if if it be here objected, that the ſolid ſubſtance, that accrues to a plant rooted in water, proceeds not at all from the water itſelf, but from the nitrous, fat, and earthy ſubſtances, that may be preſumed to abound even in common water; not here to repeat what I elſewhere ſay about this objection, I ſhall at preſent reply, that though as to divers plants, that flouriſh after rain, I am apt to think, as I intimated above, that they may in part be nouriſhed as well by the ſaline and earthy ſubſtances, to which the rain uſually proves a vehicle, as by the rain itſelf; yet as to what the objection holds forth about the plants, that grow not in the ground, but in glaſſes filled with water, it ſhould not be barely ſaid, but proved; which he will not perhaps think eaſy to be done, that conſiders how vaſt a quantity of fair water is requiſite to be exhaled away, to obtain as much as one ounce of dry reſidence, whether ſaline or earthy.

III.

THAT a plant growing in the earth doth by the faculties of its vegetative ſoul attract the juices of the earth, that are within its reach, and ſelecting thoſe parts, that are congruous to its nature, refuſe the reſt, is the general opinion of philoſophers and phyſicians: and therefore many naturaliſts are not wont much to marvel, when they ſee a tree bear a fruit, that is ſour or bitter, becauſe they preſume, that nature hath in the root of the tree culled out ſuch parts of the alimental juice of the earth, as being made to convene into one fruit, are fit to make it of ſuch a quality. But it is worth obſerving for our preſent purpoſe, what happens both in ordinary graftings, and eſpecially in that kind of inſition (taking the word in a large ſenſe) which is commonly called inoculation. For though we may preſume, that the root of a white-thorn (for inſtance) may electively attract its aliment from the earth, and chooſe that, which is fitteſt to produce the ignoble fruit, that is proper for that plant; yet we cannot reaſonably ſuppoſe, that it ſhould, in its attraction of aliment, have any deſign of providing an appropriate nutriment for a pear: and yet the known experience of gardeners, and our own obſervations manifeſt, that the cyons of a pear-tree will take very well upon a white-thorn-ſtock, and bring forth a well-taſted fruit, very differing in many qualities from that of the white-thorn. I have alſo learned from thoſe that are expert, that though apples and pears, being but vulgar fruit, are ſeldom propagated but by grafting; yet they may be propagated likewiſe by inoculation, (which ſeems to be but a kind of grafting with a bud.) Now in the inoculations, that are made upon fruit-trees, it is very obſervable, and may much countenance what we are endeavouring to prove, that a little vegetable bud, (that is no ſeed properly ſo called) not ſo big oftentimes as a pea, ſhould be able ſo to tranſmute all the ſap that arrives at it, that though this ſap be already in the root, and in its paſſage upwards determined by nature's intention, as men are wont to ſpeak, to the production of the fruit, that is natural to the ſtock; yet this ſap ſhould by ſo ſmall a vegetable ſubſtance as a bud, (whether by the help of ſome peculiar kind of ſtrainer, or by the operation of ſome powerful ferment lodged in it, or by both theſe, or ſome other cauſe) be ſo far changed and over-ruled, as to conſtitute a fruit quite otherwiſe qualified than that, which is the genuine production of the tree, and which is actually produced by thoſe other portions of the like ſap, which happened to nouriſh the prolific buds, that are the genuine offspring of the ſtock; ſo that the ſame ſap, that in one part of a branch conſtitutes (for inſtance) a cluſter of haws, in another part of the ſame branch may conſtitute a pear. And that which is further remarkable to our preſent purpoſe, is, that not only the fruits made of the ſame ſap do often differ from one another in ſhape, bigneſs, colour, odour, taſte, and other obvious qualities, as well as occult ones: but that though the ſap itſelf be (oftentimes) a wateriſh and almoſt inſipid liquor, that appears to ſenſe homogeneous enough, and even by diſtillation affords very little beſides phlegm; yet this ſap is not only convertible by buds of ſeveral natures into differing fruits, but in one and the ſame fruit the tranſmuted ſap ſhall, by differing textures, be made to exhibit very differing and ſometimes contrary qualities.

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As when (for inſtance) a peach-bud does not only change the ſap, that comes to it into a fruit, very differing from that, which the ſtock naturally produceth, but in the ſkin of the peach it muſt be red, in the kernel white, and in other parts, of other colours; the fleſh of it muſt be fragrant, the ſtone inodorous, the fleſh ſoft and yielding, the ſtone very hard and brittle, the meat pleaſantly taſted, the kernel bitter; not to mention, that peach-bloſſoms, though produced alſo by the bud, are of a colour and texture very differing from that of the fruit, and are ennobled with an occult quality, which the fruit hath not, I mean, a purgative virtue: ſo that from inoculations we may learn, that a phlegmatic liquor, that ſeems homogeneous enough, and but very ſlenderly provided with other manifeſt qualities than common water, may, by being variouſly contexted by the buds of trees, be tranſmuted into bodies endowed with new and various conſiderable ſcents, colours, taſtes, ſolidity, medicinal virtues, and divers other qualities manifeſt and occult.

If it be here ſaid, that theſe qualities are the productions of the plaſtic power reſiding in prolific buds, which indeed (to me) ſeem to be but very minute boughs; I ſhall return the ſame anſwer, that I did to the like objection, when it was propoſed in the firſt obſervation.

Hitherto I have only argued from vulgar inoculations, but there may be others, as well more conſiderable, as leſs ordinary: and I remember I have ſeen a tree, whereof, though the ſtock was of one ſort of good fruit, there were three more and differing kinds of ſtone-fruit, that had been made to take by inoculation, and two of thoſe inoculated boughs had actually fruit on them; and the third, though it had as yet no fruit, becauſe the ſeaſon for that ſort of plants to bear was not yet come, yet the ſhoot was ſo flouriſhing, that we concluded, that the bloſſoms would in due time be ſucceeded by fruit. And ſince I have been ſpeaking of the differing qualities of the parts of the ſame fruit, I am content to add two things: the one, that *Garcias ab Horto*, a claſſic author, (and phyſician to the *Indian* viceroy) affirms * with ſome ſolemnity, (as wondering that a learned man ſhould write otherwiſe) that though the fruit we call caſſia fiſtula be very commonly uſed, both here and in the *Indies*, as a purging medicine, yet the ſeeds of this ſolutive caſſia are aſtringent. The other, that of late years there have been often brought into *England* from the *Caribbe* iſlands certain kernels of a fruit, which thoſe, that have ſeen it grow, liken to a white pear-plumb; theſe are ſo ſtrongly purgative and alſo emetic, that the ingenious Mr. *Lygon* † tells us, that five of them wrought with him a dozen times upwards, and above twenty downwards; and yet the ſame author aſſures us, (which is likewiſe here a received tradition among them that are curious of this fruit,) that in the kernel, in the parting of it into halves, (as when our hazle-nuts in *England* part in the middle longways) you ſhall find a thin film, which looks of a faint carnation, (which colour is eaſily enough diſcerned, the reſt of the kernel being perfectly white,) and that taking out the film, you may eat the nut ſafely, without feeling any operation at all, and it is as ſweet as a Jordan almond. [A learned man, that practiſed phyſic in *America*, being inquired of by me concerning the truth of this relation, anſwered, that though he had divers times given thoſe nuts as cathartic remedies, yet he had not that curioſity to take out the films, finding it the univerſal belief, that the purgative faculty conſiſted therein.] And I remember, that the famous ‡ *Monardes* doth ſomewhat countenance this tradition, where, ſpeaking of another purging fruit, that alſo comes from *America*, (from *Cartagena*, and *Nombre de Dios*) he takes notice, that theſe purging beans (which are like ours, but ſmaller) have a thin ſkin, that divides them through the middle, which muſt (together with the external rind) be caſt away, elſe they will work ſo violently both upwards and downwards, as to bring the taker into hazard of his life: whereas he commends theſe beans, rightly prepared, not only as a pleaſant medicine, that doth without trouble purge both choler, phlegm, and groſs humours, for which it is celebrated among the *Indians*.

To theſe ſtories of our countrymen and *Monardes*, I ſhall ſubjoin another, which I find related by that great rambler about the world, *Vincent le Blanck*, who giving us an account of a public garden, which he viſited in *Africa*, in the territories of the Lord of *Caſima*, not far from the borders of *Nubia*, which he repreſents as the curioſeſt garden he ſaw in all the Eaſt, he mentions this among other rarities: 'There were (ſays he) other ſorts of fruit, 'which I never ſaw but there, and one among 'the reſt, leaved like a ſycamore, with fruit 'like the golden apple, but no gall more bit-'ter, and within five kernels, as big as al-'monds, the juice whereof is ſweet as ſugar; 'betwixt the ſhell and the nut there grows a 'thick ſkin of a carnation colour, which taken 'before they be thoroughly ripe, they preſerve 'with date vinegar, and make an excellent 'ſweatmeat, which they preſent to the king as 'a great curioſity.'

IV.

The fourth and laſt obſervation I ſhall at preſent mention, is afforded me by the conſideration of rotten cheeſe. For if we take notice of the difference betwixt two parts of the ſame cheeſe, whereof the one continues ſound by preſerving its texture, and the other hath ſuffered that impairing alteration of texture we call rottenneſs; we may often ſee a manifeſt and notable change in the ſeveral portions of a body, that was before ſimilar. For the rotten part will differ from the ſound in its colour, which will be ſometimes livid, but moſt commonly betwixt green and blue; and its odour, which will be both ſtrong and offenſive; and its taſte, which will be very piquant, and to

* *Aromat. Hiſt. lib.* 1. *cap.* 29. *de Caſſia ſolutiva.*
† Lygon's *Hiſtory of* Barbados *pag.* 67, 68.
‡ See *Nicholaus Monardes* under the title, *Fabæ purgatrices.*

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ſome men much more pleaſant than before, but to moſt men odious; and in divers other qualities, as particularly its conſiſtence, it will be much leſs ſolid and more friable than before; and if with a good microſcope we look upon the moulded parts of many cheeſes, we ſhall quickly diſcover therein ſome ſwarms of little animals, (the mites) furniſhed with variety of parts of differing ſizes, ſhapes, textures, &c. and deſcry a yet greater diverſity, both as to manifeſt qualities (nor probably is it inferiour as to occult ones) betwixt the mouldy part of the cheeſe and the untainted, than the unaſſiſted eye could otherwiſe have diſcovered.

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THE author would not have the reader think, that the following experiments are the ſole ones, that he could have ſet down to the ſame purpoſe with them. For they are not the only, that he had actually laid aſide for this occaſion, till judging the enſuing ones ſufficient for his preſent ſcope, he thought it fitter to reſerve others for thoſe notes about the production of particular qualities, to which they ſeemed properly to belong. Perhaps alſo it will be requiſite for me (becauſe ſome readers may think the omiſſion a little ſtrange) to excuſe my having left divers particulars unmentioned in more than one of the enſuing experiments. And I confeſs, that I might eaſily enough both have taken notice of more circumſtances in them, and made far more reflexions on them, if I would have expatiated on the ſeveral experiments, according to the directions delivered in other * papers. But though there, where it was my deſign to give employment to the curioſity and diligence of as many votaries to nature, as (for want of better inſtructions) had a mind to be ſo ſet on work, it was fit the propoſed method ſhould be ſuitable; yet here, where I deliver experiments not ſo much as part of natural hiſtory, as inſtances to confirm the hypotheſes and diſcourſes they are annexed to, it ſeemed needleſs and improper (if not impertinent) to ſet down circumſtances, cautions, inferences, hints, applications, and other particulars, that had no tendency to the ſcope, for which the experiments were alledged.

AND as for the kind of experiments here made choice of, I have the leſs ſcrupled to pitch upon chymical experiments rather than others on this occaſion; not only becauſe of thoſe advantages, which I have aſcribed to ſuch experiments in the latter part of the † preface to my Specimens, but becauſe I have been encouraged by the ſucceſs of the attempt made in thoſe diſcourſes. For as new as it was, when I made it four or five years ago, and as unuſual a thing as it could ſeem to divers Atomiſts and Carteſians, that I ſhould take upon me to confirm and illuſtrate the notions of the Particularian philoſophy (if I may ſo call it) by the help of an art, which many were pleaſed to think cultivated but by illiterate operators or whimſical fanaticks in philoſophy, and uſeful only to make medicines or diſguiſe metals: yet theſe endeavours of ours met with much leſs oppoſition, than new attempts are moſt commonly fain to ſtruggle with. And in ſo ſhort a time I have had the happineſs to engage both divers chymiſts to learn and reliſh the notions of the corpuſcular philoſophy, and divers eminent embracers of that to endeavour to illuſtrate and promote the new philoſophy, by addicting themſelves to the experiments, and peruſing the books of chymiſts. And I acknowledge, it is not unwelcome to me to have been (in ſome little meaſure) inſtrumental to make the corpuſcularian philoſophy, aſſiſted by chymiſtry, preferred to that, which has ſo long obtained in the ſchools. For (not here to conſider, which I elſewhere do, how great an advantage that philoſophy hath of this, by having an advantage of it in point of clearneſs) though divers learned and worthy men, that knew no better principles, have, in cultivating the Peripatetick ones, abundantly exerciſed and diſplayed their own wit; yet I fear they have very little, if at all, improved their reader's intellect, or enriched it with any true or uſeful knowledge of nature; but have rather taught him to admire their ſubtlety, than underſtand hers. For to aſcribe all particular phænomena, that ſeem any thing difficult, (for abundance are not thought ſo, that are ſo,) to ſubſtantial forms, and but nominally underſtood qualities, is ſo general and eaſy a way of reſolving difficulties, that it allows naturaliſts, without diſparagement, to be very careleſs and lazy, if it do not make them ſo; as in effect we may ſee, that in about two thouſand years ſince *Ariſtotle*'s time, the adorers of his phyſicks, at leaſt by virtue of his peculiar principles, ſeem to have done little more than wrangle, without clearing up (that I know of) any myſtery of nature, or producing any uſeful or noble experiment: whereas the cultivators of the particularian philoſophy, being obliged by the nature of their hypotheſis, and their way of reaſoning, to give the particular accounts and explications of particular phænomena of nature, are alſo obliged, not only to know the general laws and courſe of nature, but to inquire into the particular ſtructure of the bodies they are converſant with, as that, wherein, for the moſt part, their power of acting and diſpoſition to be acted on does depend. And in order to this, ſuch inquirers muſt take notice of abundance of minute circumſtances; and to avoid miſtaking the cauſes of ſome of them, muſt often make and vary experiments; by which means nature comes to be much more diligently and induſtriouſly ſtudied, and innumerable particulars are diſcovered and obſerved, which in the lazy Ariſtotelian way of philoſophizing would not be heeded. But to return to that

* Containing ſome advices and directions for the writing of an experimental natural hiſtory

† The preface here mentioned, is that premiſed to the tract intitled, —— *Some Specimens of an attempt to make Chymical Experiments uſeful to illuſtrate the notions of the Corpuſcular Philoſophy.*

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decade of inſtances, to which theſe advertiſements are premiſed; I hope I need not make an apology for making choice rather of chymical experiments, than others, in the ſecond and concluding ſection of the hiſtorical part of the preſent treatiſe. But though I prefer that kind of inſtances, yet I would not be thought to overvalue them in their kind, or to deny, that ſome artiſts may (for aught I know) be found, to whoſe chymical arcana theſe experiments may be little better than trifles. Nor perhaps are theſe the conſiderableſt, that I my ſelf could eaſily have communicated; (though theſe themſelves would not be now divulged, if I would have been ruled by the diſſuaſions of ſuch, as would have nothing of chymical made common, which they think conſiderable.) But things of greater value in themſelves, and of noble uſe in phyſick, may be leſs fit for our preſent purpoſe, (which is not to impart medicinal, or alchymiſtical proceſſes, but illuſtrate philoſophical notions,) than ſuch experiments as theſe; which, beſides that they contain variety of phænomena, do not (for the moſt part) require either much time, or much charge, or much ſkill.

SECTION II.

Containing the EXPERIMENTS.

Experiment I.

TAKE good and clear oil of vitriol, and caſt into it a convenient quantity of good camphire groſly beaten; let it float there a while, and, without the help of external heat, it will inſenſibly be reſolved into a liquor, which, from time to time, as it comes to be produced, you may, by ſhaking the glaſs, mingle with the oil of vitriol; whereunto you may by this means impart firſt a fine yellow, and then a colour, which though it be not a true red, will be of kin to it, and ſo very deep, as to make the very mixture almoſt quite opacous. When all the camphire is perfectly diſſolved by incorporating with the menſtruum, if you hit upon good ingredients, and upon a right proportion, (for a ſlight miſtake in either of them may make this part of the experiment miſcarry) you may probably obtain ſuch a mixture, as I have more than once had; namely, ſuch a one, as not only to me, whoſe ſenſe of ſmelling is none of the dulleſt, but alſo to others, that knew not of the experiment, ſeemed not at all to have an odour of the camphire. But if into this liquor you pour a due quantity of fair water, you will ſee (perhaps not without delight) that, in a trice, the liquor will become pale, almoſt as at the firſt, and the camphire, that lay concealed in the pores of the menſtruum, will immediately diſcloſe itſelf, and immerge in its own nature and priſtine form of white floating and combuſtible camphire, which will fill not the phial only, but the neighbouring part of the air with its ſtrong and diffuſive odour.

Now the phænomena of this experiment may, beſides the uſes we elſewhere make of it, afford us ſeveral particulars pertinent to our preſent purpoſe.

I. For (firſt) we ſee a lighter and conſiſtent body brought by a comminution into particles of a certain figure, to be kept ſwimming and mixed with a liquor, on which it floated before, and which is, by great odds, heavier than itſelf: ſo that as by the ſolution of gold in *aqua regis* it appears, that the ponderouſeſt of bodies, if it be reduced to parts minute enough, may be kept from ſinking in a liquor much lighter than itſelf; ſo this experiment of ours manifeſts, what I know not whether hitherto men have proved, that the corpuſcles of lighter bodies may be kept from emerging to the top of a much heavier liquor. Which inſtance being added to that of the gold, may teach us, that when bodies are reduced to very minute parts, we muſt as well conſider their particular texture, as the received rules of the hydroſtaticks, in determining whether they will ſink, or float, or ſwim.

II. THIS experiment alſo ſhews, that ſeveral colours, and even a very deep one, may ſoon be produced by a white body and a clear liquor, and that without the intervention of fire or any external heat.

III. AND that yet this colour may, almoſt in the twinkling of an eye, be deſtroyed, and as it were annihilated; and the latitant whiteneſs, as many would call it, may be as ſuddenly reſtored by the addition of nothing but fair water, which has no colour of its own; upon whoſe account it might be ſurmiſed to be contrary to the periſhing colour, or to heighten the other into a predominacy: nor does the water take into it ſelf either the colour it deſtroyed, or that it reſtores. For

IV. THE more than ſemi-opacity of the ſolution of camphire and oil of vitriol does preſently vaniſh; and that menſtruum, with the water, make up (as ſoon as the camphorate corpuſcles come to be afloat) one tranſparent and colourleſs liquor.

V. AND 'tis worth noting, that upon the mixture of a liquor, which makes the fluid much lighter, (for ſo water is in reſpect of vitriol) a body is made to emerge, that did not ſo, when the fluid was much heavier. This experiment may ſerve to countenance what we elſewhere argue againſt the ſchools, touching the controverſy about miſtion. For whereas though ſome of them diſſent, yet moſt of them maintain, that the elements always loſe their forms in the mixed bodies they conſtitute: and though, if they had dexterouſly propoſed their opinion, and limited their aſſertions to ſome caſes, perhaps the doctrine might be tolerated; yet ſince they are wont to propoſe it crudely and univerſally, I cannot but take notice, how little it is favoured by this experiment; wherein even a mixed body (for ſuch is camphire) doth in a further miſtion retain

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tain its form and nature, and may be immediately ſo divorced from the body, to which it was united, as to turn, in a trice, to the manifeſt exerciſe of its former qualities. And this experiment being the eaſieſt inſtance I have deviſed of the preſervation of a body, when it ſeems to be deſtroyed, and of the recovery of a body to its former conditions, I deſire it may be taken notice of, as an inſtance I ſhall after have occaſion to have recourſe to and make uſe of.

VI. BUT the notableſt thing in the experiment is, that odours ſhould depend ſo much upon texture; that one of the ſubtleſt and ſtrongeſt-ſcented drugs, that the Eaſt it ſelf, or indeed the world affords us, ſhould ſo ſoon quite loſe its odour, by being mixed with a body, that has ſcarce, if at all, any ſenſible odour of its own; and this, while the camphorate corpuſcles ſurvive undeſtroyed in a liquor, from whence one would think, that leſs ſubtile and fugitive bodies than they ſhould eaſily exhale.

VII. NOR is it much leſs conſiderable, that ſo ſtrong and piercing a ſcent as that of camphire ſhould be, in a moment, produced in a mixture, wherein none of it could be perceived before, by ſuch a liquor as water, that is quite devoid of any odour of its own: which ſo eaſy and ſudden reſtauration of the camphire to its native ſcent, as well as other qualities, by ſo languid a liquor as common water, doth likewiſe argue, that the union or texture of the two ingredients, the camphire and the oil of vitriol, was but very ſlight, upon which nevertheleſs a great alteration in point of qualities depended. And to confirm, that divers of the preceding phænomena depend upon the particular texture of the liquors imployed to exhibit them, I ſhall add, that if inſtead of oil of vitriol you caſt the concrete into well-dephlegmed ſpirit of nitre, you will obtain no red nor dark, but a tranſparent and colourleſs ſolution. And when to the above mentioned red mixture I put, inſtead of fair water, about two or three parts of duely rectified ſpirit of wine, there would enſue no ſuch changes, as thoſe formerly recited; but the ſpirit of wine, that diſſolved the concrete, when it was by it ſelf, without loſing its diaphaneity, or acquiring any colour, did, when it diſſolved the mixture, diſſolve it with its new adventitious colour, looking like a groſs red wine, ſomewhat turbid, or not yet well freed from its lees: ſo that this colour appeared to reſide in the mixture as ſuch, ſince neither of the two ingredients diſſolved in, or mingled with the ſpirit of wine, would have afforded that colour, or indeed any other. But if to this liquor, that looked like troubled wine, we poured a large proportion of fair water, the redneſs would immediately vaniſh, and the whole would, as to ſenſe, become white throughout: I ſay, as to ſenſe, becauſe the whiteneſs did not indeed appertain properly to the whole mixture, but to a huge multitude of little corpuſcles of the revived concrete, whereof ſome or other, which at firſt ſwam confuſedly to and fro, left no ſenſible portion of the liquor unfurniſhed with ſome of them; whereas when the camphirate corpuſcles had leiſure to emerge, as they ſoon did, they floated in the form of a white pouder or froth at the top of the liquor, leaving all the reſt as clear and colourleſs as the common water.

BUT we have not yet mentioned all the uſe we deſigned to make of our mixture; for by proſecuting the experiment a little further, we made it afford us ſome new phænomena.

VIII. For having kept the mixture in a moderately warm place, (which circumſtance had perhaps no influence on the ſucceſs,) and having diſtilled it out of a glaſs retort, the event anſwered our expectation, and the liquor, that came over, had a ſcent; which, though very ſtrong, was quite differing both from that of the mixture, and that of the camphire; and in the remaining body, though the liquor and the camphire it conſiſted of, were either both tranſparent, or the one tranſparent as a liquor, and the other white, as tranſparent colourleſs bodies are wont to be made by contuſion: yet the remaining maſs, which amounted to a good part of the mixture, was not only opacous, but as black as coal, in ſome places looking juſt like poliſhed jet; which is the more conſiderable, becauſe, that though vegetable ſubſtances, that are not fluid, are wont to acquire a blackneſs from the fire, yet neither do liquors, that have already been diſtilled, obtain that colour upon rediſtillation; neither have we, upon trial purpoſely made, found, that camphire, expoſed to fire in a retort, fitted with a receiver, (which was the caſe of the preſent experiment) would at all acquire a jetty colour, but would either totally aſcend white, or afford *flores* and a *caput mortuum* (as a vulgar chymiſt would call the remains) of the ſame colour, both in reſpect of one another, and in reſpect of the camphire.

IX. AND our experiment afforded this notable phænomenon, that though oil of vitriol be a diſtilled liquor, and though camphire be ſo very fugitive a ſubſtance, that being left in the air it will of itſelf fly all away, and therefore phyſicians and druggiſts preſcribe the keeping it in linſeeds or millium, or other convenient bodies, to hinder its avolation; yet, by our experiment, its fugacity is ſo reſtrained, that not only the *caput mortuum*, newly mentioned, endured a good fire in the retort, before it was reduced to that pitchy ſubſtance we were lately mentioning; but having taken ſome of that ſubſtance out of the retort, and ordered it by a careful workman to be kept in a cloſely covered crucible during ſome time in the fire, when it was brought me back, after the pot had been kept red-hot above half an hour, there remained a good quantity of the matter, brittle, without any ſmell of camphire, and as black as ordinary charcoal: ſo much do the fixity and volatility of bodies depend upon texture.

Experiment II.

AMong thoſe experiments of mine, *Pyrophilus*, which tend to manifeſt, that new qualities may be produced in bodies, as the effects of new textures; I remember, ſome years ago,

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ago, I writ for a friend a whole ſet of trials, that I had made about the changes I could produce in metals and minerals by the intervention of ſublimate. But though the whole tract, wherein they are recited, might be pertinent enough to our preſent ſubject, yet reſerving other paſſages of it for other places, (eſpecially for our notes upon thoſe particular qualities, which they are moſt proper to illuſtrate,) it may at this time ſuffice me to ſend you a tranſcript of what that account contains relating to copper and ſilver, the one a mean and fugitive, and the other a noble and fixed metal. For thoſe changes in colour, conſiſtence, fuſibleneſs, and other qualities, which you will meet with in theſe experiments, will afford us divers phænomena, to ſhew what great changes may be made, even in bodies ſcarce corruptible, by one or more of thoſe three catholic ways of nature's working according to the corpuſcular principles; namely, the acceſs, the receſs, and the tranſpoſition of the minute particles of matter.

As for my method of changing the texture of copper, I confeſs it hath oftentimes ſeemed ſtrange to me, that chymiſts, plainly ſeeing the notable effect, that ſublimate diſtilled from antimony has upon that mineral, by opening it and volatilizing it, (as we ſee it do in the making of what they are pleaſed to call *Mercurius vitæ*) ſhould not have the curioſity to try, whether or no ſublimate might not likewiſe produce, if not the ſame, yet a conſiderable change in other mineral bodies; there appearing no reaſon, or at leaſt there having been none given, that I know of, why the reſerating operation (if I may ſo ſpeak) of ſublimate ſhould be confined to antimony. Upon theſe conſiderations, we were invited to endeavour to ſupply the neglect we had obſerved in chymiſts of improving the experiment of *Butyrum Antimonii*: and though an indiſpoſition in point of health, which befel us before we had made any great progreſs in our inquiries, made us ſo ſhy of fumes of ſublimate and minerals, that we neither did make all our trials ſo accurately, nor proſecute them ſo far as we would have done, had we been to deal with more innocent materials; yet we ſuppoſe it will not be unwelcome to you to receive from us a naked, but faithful, narrative of our proceedings; being apt to think, that you will therein find inducements to carry on this experiment further than we have done, and to compleat what we have but begun.

First then, we took half a pound of copper plates, of about an inch broad, and the thickneſs of a grain of wheat, (which we after found was too great) and of an arbitrary length; then caſting a pound of groſly beaten Venetian ſublimate into the bottom of a ſomewhat deep glaſs retort, we caſt in the copper plates upon it, that the fumes of the ſublimate might, in their aſcenſion, be compelled to act upon the incumbent metal: and then placing this retort as deep as we well could in a ſand furnace, and adapting to it a ſmall receiver, we adminiſtred a gradual fire ſeven or eight hours, and at length for a while increaſed the heat, as much as we well could do in ſuch a furnace. The ſucceſs of this operation was as follows.

1. There came little or no liquor at all over into the receiver, but the neck and upper part of the retort were candied on the inſide, by reaſon of the copious ſublimate adhering to them, which ſublimate weighed above ten ounces: in the retort we found about two ounces and a quarter of running mercury, which had been ſuffered to revive by the acid ſalts, which corroding the copper, forſook the quickſilver, whereto they had been in the ſublimate united.

2. Upon the increaſe of the fire there was plainly heard a noiſe, made by the melting matter in the retort, not unlike that of a boiling pot, or of vitriol, when, being committed to a calcining fire, it is firſt brought to flow. And this noiſe we found to be a more conſtant circumſtance of this experiment, than the revivification of part of the mercury contained in the ſublimate: for upon another trial made with the former proportion of copper plates and ſublimate, we obſerved, during a very long while, ſuch a noiſe as hath been already mentioned; but the operation being finiſhed, we ſcarce found ſo much as a few grains of running mercury either in the retort or receiver.

3. We found the metalline lump in the bottom of the retort to have been increaſed in weight ſomewhat more than (though not half an ounce above) two ounces; ſome of the copper plates, lying at the bottom of the maſs, retained yet their figure and malleableneſs, which we aſcribe to their not having been thin enough to be ſufficiently wrought upon by the ſublimate: the others, which were much the greater number, had wholly loſt their metalline form, and were melted into a very brittle lump which I can compare to nothing more fitly than a lump of good benjamin. For this maſs, though ponderous, was no leſs brittle, and being broken, appeared of divers colours, which ſeemed to be almoſt tranſparent, and in ſome places it was red, in others of a high and pleaſant amber colour, and in other parts of it colours more darkiſh and mixt might be diſcerned.

4. But this ſtrange maſs, being broken into ſmaller lumps, and laid upon a ſheet of white paper in a window, was by the next morning, where-ever the air came at it, all covered with a lovely greeniſh blue, or rather bluiſh green, almoſt like that of the beſt verdigreeſe; and the longer it lay in the air, the more of the internal parts of the fragments did paſs into the ſame colour: but the white paper, which in ſome places they ſtranned, ſeem dyed of a green colour inclining unto yellow. And here we had occaſion to take notice of the inſinuating ſubtilty of the air; for having put ſome pieces of this cupreous gum (if I may ſo call it) into a little box, to ſhut out the air, which we have found it poſſible to exclude by other means, we found, that notwithſtanding our care thoſe included fragments were, as well as the reſt already mentioned, covered with the powder as it were of *viride æris*.

5. We muſt not on this occaſion omit to tell you, that having the laſt year made ſome trials in reference to this experiment, we obſerved

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ſerved in one of them, that ſome little copper-plates, from which ſublimate had been drawn off, retained their priſtine ſhape and metalline nature, but were whitened over like ſilver, and continued ſo for divers months; (though we cannot preciſely tell you how long, having at length accidentally loſt them.) And to try whether this whiteneſs were only ſuperficial, we purpoſely broke ſome of theſe flexible plates, and found, that this ſilver colour had penetrated them throughout, and was more glorious in the very body of the metal, than on its ſurface; which made us ſuſpect, that the ſublimate by us imployed had been adulterated with arſenick, (wherewith the ſophiſticators of metals are wont to make blanchers for copper, but not to mention, that the malleableneſs continued, which arſenick is wont to deſtroy) we diſcovered not by trial, that the ſublimate was other than ſincere.

6. IN this metalline gum the body of the copper appeared ſo changed and opened, that we were invited to look upon ſuch a change as no ignoble experiment, conſidering the difficulty, which the beſt artiſts tell us there is, and which thoſe, that have attempted it, have found; I ſay, not to unlock the ſulphur of Venus, but to effect leſs changes in its texture, than was hereby made. For this gum, caſt upon a quick coal and a little blown, will partly melt and flow like roſin, and partly flame and burn like a ſulphur, and with a flame ſo laſting, if it be rekindled as often as it leaves off burning, that we obſerved it, not without ſome wonder; and ſo inflammable is this opened copper, that being held to the flame of a candle or a piece of lighted paper, it would almoſt in a moment take fire, and ſend forth a flame like common ſulpur, but only that it ſeemed to us to incline much more to a greeniſh colour, than the bluer flame of brimſtone is wont to do.

To theſe phænomena of our experiment, as it was made with copper, my notes enable me to ſubjoin ſome others, exhibited, when he made it with ſublimate and ſilver.

THERE were taken of the pureſt ſort of coined ſilver we could get, half a ſcore of thin plates, on which was caſt double the weight of ſublimate in a ſmall and ſtrongly-coated retort. This matter being ſublimed in a naked fire, we found, (having broken the veſſel) that the ſublimate was almoſt totally aſcended to the top and neck of the retort; in the latter of which, appeared in many places ſome revived mercury; in the bottom of the retort we found a little fluxed lump of matter, which it was ſcarce poſſible to ſeparate from the glaſs; but having, with much ado, divorced them, we found this maſs to be brittle, of a pale yellowiſh colour, of near about the weight of the metal, on which the ſublimate had been caſt. And in the thicker part of this lump there appeared, when it was broken, ſome part of the ſilver plates, which, though brittle, ſeemed not to have been perfectly diſſolved. This reſin of ſilver did, like that of copper, but more ſlowly, imbibe the moiſture of the air, and within about twenty-four hours, was covered with a ſomewhat greeniſh duſt, concerning which we durſt not determine, whether it proceeded from that mixture of copper, which is generally to be met with in coined ſilver, or from the compounded metal. For the more curious ſort of painters do, as they inform us, by corroding coined ſilver with the fretting ſteams of ſaline bodies, or with corroſive bodies themſelves, turn it into a fine kind of azure, as we may elſewhere have opportunity more particularly to declare. I ſhall now only add, that ſome ſmall fragments of our reſin being caſt upon red-hot coals, did there waſte themſelves in a flame, not very differing in colour from that of the former mentioned reſin of copper, but much more durable, than would have been eaſily expected from ſo ſmall a quantity of matter.

THIS is all the account I can give you of our firſt trial; but ſuſpecting, that the copper wont to be mixed as an alloy with our coined ſilver might have too much influence on the recited event, coming afterwards into a place, where we could procure refined ſilver, we took an ounce of that, and having laminated it, we caſt it upon twice its weight of beaten ſublimate, which being driven away from it with a ſomewhat ſtrong fire, we took out of the bottom of the glaſs retort a lump of matter, which in ſome places, where it lay next the glaſs, was as it were ſilvered over very finely, but ſo very thinly, that the thickneſs of the ſilver ſcarce equalled that of fine white paper; the reſt of the metal (except a little, that lay undiſſolved almoſt in the middle of the maſs, becauſe, as we ſuppoſed, the plates had not been beaten, till they were ſufficiently and equally thin) having been, by the ſaline part of the ſublimate, that ſtuck to it, colliquated into a maſs, that looked not at all like ſilver, or ſo much as any other metal or mineral.

AND it is remarkable, that though ſilver be a fixed metal, and accounted indeſtructible, yet it ſhould by ſo ſlight an operation, and by but about a quarter of its weight of additament, (as appeared by weighing the whole lump) be ſo ſtrangely diſguiſed, and have its qualities ſo altered.

FOR (firſt) though an eminent whiteneſs be accounted the colour, which belongs to pure ſilver, and though beaten ſublimate be alſo eminently white; yet the maſs we are ſpeaking of was partly of a lemon or amber colour, or a deep amethyſtine colour, and partly of ſo dark an one, as it ſeemed black: and it was pretty, that ſometimes in a fragment, that ſeemed to be one continued and entire piece, the upper part would be of a light yellow, which abruptly ending, the lower was of a colour ſo obſcure, as ſcarce to challenge any name diſtinct from black.

NEXT, Whereas ſilver is one of the moſt opacous bodies in nature, and ſublimate a white one, the produced maſs was in great part tranſparent, though not like glaſs, yet like good amber.

THIRDLY, The texture of the ſilver was exceedingly altered; for our maſs, inſtead of being malleable and flexible, as that metal is

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very much, appeared, if you went about to cut it with a knife, like horn, yet otherwiſe eaſily apt to crack and break, though not at all to bend.

FOURTHLY, Whereas ſilver will endure ignition for a good while, before it be brought to fuſion, our mixture will eaſily melt, not only upon quick coals, but in the flame of a candle; but this reſin, or gum (if I may ſo call it) of our fixed metal did not, like that we formerly deſcribed of copper, tinge the flame of a candle, or produce with the glowing coals, on which it is laid, either a green or bluiſh colour.

AND, *Pyrophilus*, to diſcover, how much theſe operations of the ſublimate upon copper and ſilver depend upon the particular textures of theſe bodies, I took two parcels of gold, the one common gold thinly laminated, and the other very well refined, and having caſt each of theſe in a diſtinct urinal upon no leſs than thrice its weight of groſly beaten ſublimate, I cauſed this laſt named ſubſtance to be in a ſand-furnace elevated from the gold, but found not, that either of the two parcels of that metal was manifeſtly altered thereby: whether in caſe the gold had been reduced to very minute particles, ſome kind of change (perhaps, if any, differing enough from thoſe lately recited to have been made in the copper and the ſilver) might have been made in it, I am not ſo abſolutely certain; but I am confident, that by what I reſerve to tell you hereafter of ſublimates operation upon ſome other minerals, eſpecially tin, it will appear, that that operation depends very much upon the particular texture of the body, from whence that ſublimate is elevated.

BEFORE I diſmiſs this ſubject, *Pyrophilus*, I muſt not conceal from you, that in the papers, whence theſe experiments made with ſublimate have been tranſcribed, I annexed to the whole diſcourſe a few advertiſements, whereof the firſt was, that I was reduced in thoſe experiments to imploy, for want of a better, a ſand-furnace, wherein I could not give ſo ſtrong a fire as I deſired; which circumſtance may have had ſome influence upon the recited phænomena; and among other advertiſements there being one, that will not be impertinent to my preſent deſign, and may poſſibly afford a not unſucceſsful hint, I ſhall ſubjoin it in the words, wherein I find it delivered.

THE next thing, of which I am to advertiſe you, is this, that this experiment may probably be further improved by imploying about it various and new kinds of ſublimate; and that ſeveral other things may be ſublimed up together either with crude mercury or with common ſublimate, he, that conſiders the way of making vulgar ſublimate, will not, I ſuppoſe, deny. To give you only one inſtance, I ſhall inform you, that, having cauſed about equal parts of common ſublimate and ſal armoniack to be well powdered and incorporated, by ſubliming the mixture in ſtrong and large urinals placed in a ſand-furnace, we obtained a new kind of ſublimate, differing from the former, which we manifeſted *ad oculum*, by diſſolving a little of it and a little of common ſublimate ſeverally in fair water: for dropping a little reſolved ſalt of tartar upon the ſolution of common ſublimate, it immediately turned of an orange-tawny colour; but dropping the ſame liquor upon the ſolution of the armoniack ſublimate, if I may ſo call it, it preſently turned into a liquor, in whiteneſs reſembling milk. And having from four ounces of copper-plates drawn ſix ounces of this new ſublimate after the already often recited manner, we had indeed in the bottom of the retort a cupreous reſin, not much unlike that, made by copper and common ſublimate; and this reſin did, like the other, in the moiſt air ſoon begin to degenerate into a kind of verdigreeſe. But that, which was ſingular in this operation, was, that not only ſome of the ſublimate had carried up, to a good height, enough of the copper to be manifeſtly coloured by it of a fine bluiſh green, but into the receiver there was paſſed near an ounce of liquor, that ſmelt almoſt like ſpirit of ſal armoniack, and was tincted like the ſublimate, ſo that we ſuppoſed the body of the *Venus* to have been better wrought upon by this, than by the former ſublimate. And yet I judged not this way to be the moſt effectual way of improving common ſublimate, being apt to think, upon grounds not now to be mentioned, that it may by convenient liquors be ſo far enriched and advanced, as to be made capable of opening the compact body of gold it ſelf, and of producing in it ſuch changes, (which yet perhaps will enrich but men's underſtandings) as chymiſts are wont very fruitleſly to attempt to make in that almoſt indeſtructible metal. But of this, having now given you a hint, I dare here ſay no more.

Experiment III.

THERE is, *Pyrophilus*, another experiment, which many will find more eaſy to be put in practice, and which yet may, as to ſilver, be made a kind of ſuccedaneum to the former, and conſequently may ſerve to ſhew, how the like qualities in bodies may be effected by differing ways, provided a like change of texture be produced by them. Of this I ſhall give you an example in that preparation of ſilver, that ſome chymiſts have called *Luna Cornea*, which I ſhall not ſcruple to mention particularly, and apply to my preſent purpoſe; becauſe though the name of *Luna Cornea* be already to be met with in the writings of ſome alchymiſts, yet the thing itſelf, being not uſed in phyſick, is not wont to be known by thoſe, that learn chymiſtry in order to phyſick; and the way that I uſe in making it is differing from that of alchymiſts, being purpoſely deſigned to ſhew ſome notable phænomena, not to be met with in their way of proceeding.

WE take then refined ſilver, and having beaten it into thin plates, and diſſolved it in about twice its weight of good aqua fortis, we filtrate it carefully to obtain a clear ſolution, (which ſometimes we evaporate further, till it ſhoot into cryſtals, which we afterwards dry upon brown paper with a moderate heat.)

UPON the abovementioned ſolution we drop good ſpirit of ſalt, till we find, that it will no more

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more curdle the liquor it falls into, (which will not happen ſo ſoon, as you will be apt at firſt to imagine;) then we put the whole mixture in a glaſs funnel lined with cap-paper, and letting the moiſture drain through, we dry with a gentle heat the ſubſtance, that remains in the filtre, firſt waſhing it (if need be) from the looſly adhering ſalts, by letting fair water run through it ſeveral times, whilſt it yet continues in the filtre. This ſubſtance being well dried, we put it into a glaſs phial, which being put upon quick coals firſt covered with aſhes, and then freed from them, we melt the contained ſubſtance into a maſs, which, being kept a while in fuſion, gives us the *Luna Cornea* we are now to conſider.

IF to make this factitious concrete, we firſt reduce the ſilver into cryſtals, and afterwards proceed with ſpirit of ſalt, as we have juſt now taught you to do with the ſolution, we have the exceedingly opacous, malleable, and hardly fuſible body of ſilver, by the convenient interpoſition of ſome ſaline particles, not amounting to the third part of the weight of the metal, reduced into cryſtals, that both ſhoot in a peculiar and determinate figure, differing from thoſe of other metals, and alſo are diaphanous and brittle, and by great odds more eaſily fuſible than ſilver it ſelf, beſides other qualities, wherein having elſewhere taken notice, that theſe cryſtals differ both from ſilver and from aqua-fortis, we ſhall not now inſiſt on them, but paſs to the qualities, that do more properly belong to the change of the ſolution of ſilver into *Luna Cornea*.

FIRST then we may obſerve, that though ſpirit of ſalt be an highly acid liquor, and though acid liquors and alkalies are wont to have quite contrary operations, the one precipitating what the other would diſſolve, and diſſolving what the other would precipitate; yet in our caſe, as neither oil of tartar *per deliquium*, nor ſpirit of ſalt will diſſolve ſilver, ſo both the one and the other will precipitate it; which I deſire may be taken notice of againſt the doctrine of the vulgar chymiſts, and as a proof, that the precipitation of bodies depends not upon acid or alkalizate liquors as ſuch, but upon the texture of the bodies, that happen to be confounded.

2. WE may here obſerve, that whiteneſs and opacity may be immediately produced by liquors, both of them diaphanous and colourleſs.

3. THAT, on the other ſide, a white powder, though its minute parts appear not tranſparent, like thoſe of beaten glaſs, reſin, *&c.* which, by comminution, are made to ſeem white, may yet, by a gentle heat, be preſently reduced into a maſs indifferently tranſparent, and not at all white, but of a fair yellow.

4. WE may obſerve too, that though ſilver require ſo ſtrong a fire to melt it, and may be long kept red-hot, without being brought to fuſion; yet by the aſſociation of ſome ſaline particles conveniently mingled with it, it may be made ſo fuſible, as to be eaſily and quickly melted, either in a thin phial, or at the flame of a candle, where it will flow almoſt like wax.

5. IT may alſo be noted, that though the lunar ſolutions and the ſpirit of ſalt would, either of them apart, have readily diſſolved in water; yet when they are mingled, they do, for the moſt part, coagulate into a ſubſtance, that will lie undiſſolved in water, and is ſcarce, if at all, ſoluble either in aqua fortis or in ſpirit of ſalt.

6. AND remarkable it is, that the body of ſilver being very flexible and malleable, (eſpecially if the metal be, as ours was, refined) it ſhould yet, by the addition of ſo ſmall a proportion of ſalt, (a body rigid and brittle) as is aſſociated to it in our experiment, be made of a texture ſo differing from what either of its ingredients was before, being wholly unlike either a ſalt or a metal, and very like in texture to a piece of horn. And to ſatisfy my ſelf how much the toughneſs of this metalline horn depended upon the texture of the *compoſitum*, reſulting from the reſpective textures of the ſeveral ingredients, I precipitated a ſolution of ſilver with the diſtilled ſaline liquor commonly called oil of vitriol, inſtead of ſpirit of ſalt; and having waſhed the precipitate with common water, I found, agreeably to my conjecture, that this precipitate, being fluxed in a moderate heat, afforded a maſs, that looked like enough to the concrete we have been diſcourſing of, but had not its toughneſs, being brittle enough to be eaſily broken in pieces. But the two conſiderableſt phænomena of our experiment do yet remain unmentioned.

FOR, 7thly, it is odd, that whereas a ſolution of ſilver is, as we have often occaſion to note, the bittereſt liquor we have ever met with, and the ſpirit of ſalt far ſourer than either the ſharpeſt vinegar, or even the ſpirit of it, theſe two ſo ſtrongly and offenſively taſted liquors ſhould be ſo eaſily and ſpeedily, without any other thing to correct them, be reduced into an inſipid ſubſtance, (at leaſt ſo far inſipid, that I have licked it ſeveral times with my tongue, without finding it otherwiſe, though perhaps with much rolling it to and fro in the mouth, it may at length afford ſome unpleaſant taſte, but exceedingly different from that of either of the liquors, that compoſed it:) and this, though the ſalts, that made both the ſilver and the precipitating ſpirit ſo ſtrongly taſted, remain aſſociated with the ſilver.

8. AND laſtly, it is very ſtrange, that though the ſaline corpuſcles, that give the efficacy both to good aqua fortis and the like ſpirit of ſalt, be not only ſo volatile, that they will eaſily be diſtilled with a moderate fire, but ſo fugitive, that they will in part fly away of themſelves in the cold air, (as our noſes can witneſs to our trouble, when the phials, that contain ſuch liquors, are unſtopped;) yet by virtue of the new texture they acquire by aſſociating themſelves with the corpuſcles of the ſilver and with one another, theſe minute particles of ſalt loſe ſo much of their former lightneſs, and acquire ſuch a degree of fixedneſs, that they will endure melting with the metal they adhere to, rather than ſuffer themſelves to be driven away from it. Nor do I remember, that when I melted this maſs in a thin phial, I could perceive any ſenſible evaporation of the matter: nay, having afterwards put a parcel of

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it upon a quick coal, though that were blown to intend the heat; yet it ſuffered fuſion, and ſo ran off from the coal, without appearing, when it was taken up again, to be other than *Luna Cornea*, as it was before.

Experiment IV.

I AM now, *Pyrophilus*, about to do a thing, contrary enough both to my cuſtom and inclination; that is, to diſcourſe upon the phænomena of an experiment, which I do not teach you to make. But ſince I cannot as yet, without ſome breach of promiſe, plainly diſcloſe to you what I muſt now conceal, your equity aſſures me of your pardon. And as becauſe the qualities of the ſalt I am to ſpeak of are very remarkable, and pertinent to my preſent purpoſe, I am unwilling to paſs them by unmentioned; ſo I hope, that, notwithſtanding their being ſtrange, I may be allowed to diſcourſe upon them to you, who, I preſume, know me too well to ſuſpect I would impoſe upon you in matters of fact, and to whom I am willing (if you deſire it) to ſhew the anomalous ſalt it ſelf, and ocular proofs of the chief properties I aſcribe to it.

I SHALL not then ſcruple to tell you, that diſcourſing one day with a very ingenious traveller and chymiſt, who had had extraordinary opportunities to acquire ſecrets, of a certain odd ſalt I had thought upon and made, which was of ſo differing a kind from other ſalts, that though I did not yet know what feats I ſhould be able to do with it, yet I was confident it muſt have noble and unuſual operations: this gentleman, to requite my frankneſs, told me, that I had lighted on a greater jewel than perhaps I was aware of; and that if I would follow his advice, by adding ſomething, that he named to me, and proſecuting the preparation a little further, I ſhould obtain a ſalt exceedingly noble. I thanked him, as I had cauſe, for his advice, and when I had opportunity, followed it. And though I found the way of making this ſalt ſo nice and intricate a thing, that if I would, I could ſcarce eaſily deſcribe it, ſo as to enable moſt men to practiſe it; yet having once made it, I found, that beſides ſome of the things I had been told it would perform, I could do divers other things with it, which I had good cauſe to believe the gentleman of whom I was ſpeaking did not think of; and I doubt not, but I ſhould have done much more with it, if I had not unfortunately loſt it ſoon after I had prepared it.

SEVERAL of the phænomena I tried to produce with it, which are not ſo proper for this place, are reſerved for another; but here I ſhall mention a few, that beſt fit my preſent purpoſe.

FIRST then, though the ſeveral ingredients, that compoſed this ſalt, were all of them ſuch, as vulgar chymiſts muſt, according to their principles, look upon as purely ſaline, and were each of them far more ſalt than brine, or more ſour than the ſtrongeſt vinegar, or more ſtrongly taſted than either of thoſe two liquors; yet the compound, made up of only ſuch bodies, is ſo far from being eminently ſalt, or ſour, or inſipid, that a ſtranger being aſked what taſte it had, would not ſcruple to judge it rather ſweet, than of any other taſte; though its ſweetneſs be of a peculiar kind, as there is a difference even among bodies ſweet by nature; the ſweetneſs of ſugar being diverſe from that of honey, and both of them differing from that of the ſweet vitriol of lead. And this is the only inſtance I remember I have hitherto met with of ſalts, that, without the mixture of inſipid bodies, compoſe a ſubſtance really ſweet. I ſay, really ſweet, becauſe chymiſts oftentimes term the calces of metals, and other bodies dulcified, if they be freed from all corroſive ſalts and ſharpneſs of taſte, ſweet, though they have nothing at all of poſitive ſweetneſs in them; and by that licence of ſpeaking do often enough impoſe upon the unſkilful.

ANOTHER thing conſiderable in our anomalous ſalt is, that though its odour be not either ſtrong or offenſive, (both which that of volatile ſalts is wont to be;) yet if it be a little urged with heat, ſo as to be forced to evaporate haſtily and copiouſly, I have known ſome, that have been uſed to the powerful ſtink of aqua fortis, diſtilled urine, and even ſpirit of ſal armoniack itſelf, that have complained of this ſmell as more ſtrong, and upon that account more unſupportable than theſe themſelves: and yet when theſe fumes ſettle again into a ſalt, their odour will again prove mild and inoffenſive, if not pleaſant.

THIRDLY, Whereas allthe volatile and acid and lixiviate ſalts, that we know of, are of ſo determinate and ſpecificated a nature, if I may ſo ſpeak, that there is no one ſort of the three, but may be deſtroyed by ſome one or other of the other two ſalts, if not by both; as ſpirit of urine, which is a volatile ſalt, being mingled with ſpirit of ſalt or aqua fortis or almoſt any other ſtrong and acid ſpirit, will make a great ebullition, and loſe its peculiar taſte, and ſeveral of its other qualities; and, on the other ſide, ſalt of tartar and other alkalies, (that is, ſalts produced by incineration of mixed bodies) will be deſtroyed with ebullition by aqua fortis, ſpirit of ſalt, or almoſt any other ſtrong ſpirit of that family: and ſpirit of ſalt, aqua fortis, *&c.* will be (as they ſpeak) deſtroyed both by animal volatile ſalts, and by the fixed ſalts of vegetables; that is, will make an efferveſcence with either ſort of ſalts, and compoſe with them a new liquor or ſalt, differing from either of the ingredients, and, as to taſte, ſmell, odour, and divers other qualities, more languid and degenerous: whereas, I ſay, each of theſe three families of ſalts may be eaſily deſtroyed by the other two, our anomalous ſalt ſeems to be above the being thus wrought upon by any of all the three, and is the only body I know; (which is no ſmall privilege, or rather prerogative:) For I did not find, that a ſolution of it, made with as little water as I could, which is the way whereby we uſually make it fluid, would make any ebullition either with oil of tartar *per deliquium*, or ſpirit of ſal armoniack, or ſtrong ſpirit of ſalt, or even oil of vitriol, but would calmly and ſilently

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lently mix with theſe differing liquors, and continue as long as I had patience to look upon them, without being precipitated by them. But this is not the only way I employed, to examine, whether our ſalt belonged to any of the three abovementioned comprehenſive families of ſalts. For I found not, that the ſtrongeſt ſolution of it would turn ſyrup of violets either red, as acid ſpirits do, or green, as both fixed and volatile ſalts will do. Nor would our ſolution turn a clear one of ſublimate made in common water either white, as ſpirit of urine, ſal armoniack, or others of the ſame family, or into an orange-tawny, like ſalt of tartar, and other alkalies; but left the ſolution of ſublimate tranſparent, without giving it any of theſe colours, mingling itſelf very kindly with it, as it had done with the four lately mentioned liquors. And to ſatisfy my ſelf a little further, I not only tried, that an undiſcoloured mixture of ſyrup of violets and our ſolution would immediately be turned red by two or three drops of ſpirit of ſalt, or green by as much oil of tartar; but to proſecute the experiment, I let fall a drop or two of a mixture made of our anomalous ſolution, and ſpirit of ſalt well ſhaken together, upon ſome ſyrup of violets; which was thereby immediately turned red, and a little of the ſame anomalous ſolution, being ſhaken together with oil of tartar *per deliquium*, turned another parcel of the ſame ſyrup of violets into a delightful green; which, happening as I expected, ſeemed to argue, that our ſolution, though as to ſenſe it were exquiſitely mingled in the ſeveral mixtures, to which I had put it, did, as it left them their undeſtroyed reſpective natures, retain its own: and yet this ſalt is ſo far from being a languid or an inſignificant thing, that aqua fortis, and oil of vitriol themſelves, as operative and as furious liquors as they are, are unable in divers caſes to make ſuch ſolutions, and perform ſuch other things, as our calm but powerful menſtruum can, though but ſlowly, effect.

FOURTHLY, Though this ſalt be a volatile one, and requires no ſtrong heat to make it ſublime into finely figured cryſtals without a remanence at the bottom; yet being diſſolved in liquors, you may make the ſolution, if need be, to boil, without making any of the ſalt ſublime up, before the liquor be totally or almoſt totally drawn off; whereas the volatile ſalt of urine, blood, hartſhorn, *&c.* are wont to aſcend before almoſt any part of the liquor they are diſſolved in, which is in many caſes very inconvenient.

AND though this be a volatile ſalt, yet I remember not, that I have obſerved any fixed ſalt, (without excepting ſalt of tartar itſelf) that runs near ſo ſoon *per deliquium*, as this will do; but by abſtraction of the adventitious moiſture, it is eaſily reſtored to its former ſaline form, and yet differs from ſalt of tartar, not only in fixedneſs and taſte, and divers other qualities, but alſo in this, that, whereas ſalt of tartar requires a vehement fire to flux it, a gentler heat, than one would eaſily imagine, will melt our ſalt into a limpid liquor.

AND whereas ſpirit of wine will diſſolve ſome bodies, as ſanderick, maſtick, gum-lac, *&c.* and water, on the other ſide, diſſolves many, that ſpirit of wine cannot, and oils will diſſolve ſome, for which neither of the other liquors are good ſolvents; our ſalt will readily diſſolve both in fair water, in the higheſt rectified ſpirit of wine, (and that ſo little, as not to weigh more than the ſalt) and in chymical oils themſelves, with which it will aſſociate itſelf very ſtrictly, and perhaps more too, than I have yet found any other conſiſtent ſalt to do.

Experiment V.

THE experiment I am, *Pyrophilus*, now about to deliver, though I have not yet had opportunity to perfect what I deſigned, when ſome notions, that I have about fire and ſalt, ſuggeſted it to me, is yet ſuch, as may far more clearly, than almoſt any of the experiments commonly known to chymiſts, ſerve to ſhew us, how near to a real tranſmutation thoſe changes may prove, that may be effected even in inanimate, and, which is more, ſcarce corruptible bodies, by the receſs of ſome particles, and the acceſs of ſome others, and the new texture of the reſidue. The experiment I have made ſeveral ways, but one of the lateſt and beſt I have uſed is this: Take one part of good ſea-ſalt well dried and powdered, and put to it double its weight of good aqua fortis or ſpirit of nitre; then having kept it (if you have time) for ſome while in a previous digeſtion, diſtil it over with a ſlow fire in a retort or a low body, till the remaining matter be quite dry, and no more: for this ſubſtance, that will remain in the bottom of the glaſs, is the thing, that is ſought for.

THIS operation being performable in a moderate fire, and the bodies themſelves being almoſt of an incorruptible nature, one would ſcarce think, that ſo ſlight a matter ſhould produce any change in them; but yet I found, as I expected, theſe notable mutations of qualities effected by ſo unpromiſing a way.

FOR in the firſt place, we may take notice, that the liquor, that came over, was no longer an aqua fortis, or ſpirit of nitre, but an aqua regis, that was able to diſſolve gold; which aqua fortis will not meddle with, and will not diſſolve ſilver, as it would have done before; but will rather, as I have purpoſely tried, precipitate it out of aqua fortis, if that menſtruum have already diſſolved it. But this change belonging not ſo properly to the ſubſtance it ſelf I was about to conſider, I ſhall not here inſiſt on it.

2. THEN, the taſte of this ſubſtance comes by this operation to be very much altered. For it hath not that ſtrong ſaltneſs, that it had before, but taſtes far milder; and though it reliſh of both, affects the palate much more like ſalt-petre, than like common ſalt.

3. NEXT, whereas this laſt-named body is of very difficult fuſion, our factitious ſalt imitates ſalt-petre in being very fuſible; and it will, like nitre ſoon melt, by being held in the flame of a candle.

4. BUT to proceed to a more conſiderable phænomenon, it is known, that ſea-ſalt is a body, that doth very much reſiſt the fire; when once, by being brought to fuſion, it hath been

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forced to let go that windy ſubſtance, that makes unbeaten ſalt crackle in the fire, and ſo by blowing it accidentally increaſe it. It is alſo known, that acid ſpirits, as thoſe of ſalt, vitriol, nitre, vinegar, *&c.* are not only not inflammable themſelves, but hinderers of inflammation in other bodies; and yet my conjecture leading me to expect, that by this operation I ſhould be able to produce out of two uninflammable bodies a third, that would be eaſily inflammable, I found upon trial not only that ſmall lumps of this ſubſtance, caſt upon quick and well-blown coals, though they did not give ſo blue a flame as nitre, did yet, like it, burn away with a copious and vehement flame. And, for further trial, having melted a pretty quantity of this tranſmuted ſea-ſalt in a crucible, by caſting upon it little fragments of well-kindled charcoal, it would, like nitre, preſently be kindled, and afford a flame ſo vehement and ſo dazling, that one, that had better eyes than I, and knew not what it was, complained, that he was not able to ſupport the ſplendour of it. Nor were all its inflammable parts conſumed at one deflagration: for by caſting in more fragments of well-kindled coal, the matter would fall a puffing, and flame afreſh for ſeveral times conſecutively, according to the quantity, that had been put into the crucible.

5. But this itſelf was not the chief diſcovery I deſigned by this experiment. For I pretended hereby to deviſe a way of turning an acid ſalt into an alkali, which ſeems to be one of the greateſt and difficulteſt changes, that is rationally to be attempte among durable and inanimate bodies. For it is not unknown to ſuch chymiſts, as are any thing inquiſitive and heedful, how vaſt a difference there is between acid ſalts, and thoſe, that are made by the combuſtion of bodies, and are ſometimes called fixed, ſometimes alkalizate. For whereas ſtrong lixiviums (which are but ſtrong ſolutions of alkalies) will readily enough diſſolve common ſulphur, and divers other bodies abounding with ſulphur, even thoſe highly acid liquors, aqua fortis and aqua regis, though ſo corroſive, that one will diſſolve ſilver and the other gold itſelf, will let brimſtone lie in them undiſſolved I know not how long; though ſome ſay, that in proceſs of time there may be ſome tincture drawn by the menſtruum from it, which yet I have not ſeen tried, and though it were true, would yet ſufficiently argue a great diſparity betwixt thoſe acid ſpirits and ſtrong alkalizate ſolutions, which will ſpeedily diſſolve the very maſs of common ſulphur. Beſides, it is obſerved by the inquiſitive chymiſts, nor does my experience contradict it, that the bodies, that are diſſolved by an acid menſtruum, may be precipitated by an alkalizate; and on the contrary, ſolutions made by the latter may be precipitated by the former. Moreover, as litharge diſſolved in ſpirit of vinegar will be precipitated by the oil of tartar *per deliquium*, or the ſolution of its ſalt; and, on the contrary, ſulphur or antimony diſſolved in ſuch a ſolution will be precipitated out of it by the ſpirit of vinegar, or even common vinegar: Moreover, acids and alkalizates do alſo differ exceedingly in taſte, and in this greater diſparity, that the one is volatile, and the other fixed, beſides other particulars not neceſſary here to be inſiſted on. And indeed if that were true, which is taught in the ſchools, that there is a natural enmity, as well as diſparity betwixt ſome bodies, as between oily and wateriſh ones, the chymiſts may very ſpeciouſly teach, (as ſome of them do) that there is a ſtrange contrariety betwixt acid and alkalizate ſalts; as when there is made an affuſion of oil of tartar upon aqua regis or aqua fortis, to precipitate gold out of the one, and ſilver out of the other, their mutual hoſtility ſeems manifeſtly to ſhew itſelf, not only by the noiſe, and heat, and fume, that are immediately excited by their conflict, but by this moſt of all, that afterwards the two contending bodies will appear to have mutually deſtroyed one another, both the four ſpirit and the fixed ſalt having each loſt its former nature in the ſcuffle, and degenerated with its adverſary into a certain third ſubſtance, that wants ſeveral of the properties both of the four ſpirit and the alkali. Now to apply all this to the occaſion, on which I mentioned it, how diſtant and contrary ſoever the more inquiſitive of the latter chymiſts take acid and fixed ſalts to be; yet I ſcarce doubted, but that, by our experiment, I ſhould from acid ſalts obtain an alkali; and accordingly having, by caſting in ſeveral bits of well-kindled coal, excited in the melted maſs of our tranſmuted ſalt, as many deflagrations as I could, and then giving it a pretty ſtrong fire to drive away the reſt of the more fugitive parts, I judged, that the remaining maſs would be (like the fixed nitre I have elſewhere mentioned) of an alkalizate nature; and accordingly having taken it out, I found it to taſte, not like ſea-ſalt, but fiery enough upon the tongue, and to have a lixiviate reliſh. I found too, that it would turn ſyrup of violets into a greeniſh colour, that it would precipitate a limpid ſolution of ſublimate, made in fair water, into an orange-tawny powder. I found, that it would, like other fixed ſalts, produce an ebullition with acid ſpirits, and even with ſpirit of ſalt it ſelf, and concoagulate with them. Nor are theſe themſelves all the ways I took to manifeſt the alkalizate nature of our tranſmuted ſea-ſalt.

I Did indeed conſider at firſt, that it might be ſuſpected, that this new alkalizateneſs might proceed from the aſhes of the injected coals, the aſhes of vegetables generally containing in them more or leſs of a fixed ſalt. But when I conſidered too, that a pound of charcoal, burned to aſhes, is wont to yield ſo very little ſalt, that the injected fragments of coal (though they had been, which they were not) quite burned out in this operation would ſcarce have afforded two or three grains of ſalt, (perhaps not half ſo much) I ſaw no reaſon at all to believe, that in the whole maſs I had obtained, (and which was all, that was left me of the ſea-ſalt, I had firſt imployed,) it was nothing but ſo inconſiderable a proportion of aſhes, that exhibited all the phænomena of an alkali.

And for further confirmation both of this, and what I ſaid a little before, I ſhall add, that

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that to ſatisfy my ſelf yet more, I poured upon a pretty quantity of this lixiviate ſalt a due proportion of aqua fortis, till the hiſſing and ebullition ceaſed, and then leaving the fluid mixture for a good while to coagulate, (which it did very ſlowly) I found it at length to ſhoot into ſaline cryſtals; which, though they were not of the figure of nitre, did yet, by their inflammability and their bigneſs, ſufficiently argue, that there had been a conjunction made betwixt the nitrous ſpirit, and a conſiderable proportion of alkali.

I conſidered alſo, that it might be ſuſpected, that in our experiment it was the nitrous corpuſcles of the aqua fortis, that, lodging themſelves in the little rooms deſerted by the ſaline corpuſcles of the ſea-ſalt, that paſſed over into the receiver, had afforded this alkali; as common ſalt-petre, being handled after ſuch a manner, would leave in the crucible a fixt or alkalizate ſalt. But to this I anſwer, that as the ſea-ſalt, which was not driven over by ſo mild a diſtillation, and ſeemed much a greater part than that which had paſſed over, was far from being of an alkalizate nature; ſo the nitrous corpuſcles, that are preſumed to have ſtaid behind, were, whilſt they compoſed the ſpirit of nitre, of an highly volatile and acid nature, and conſequently of a nature directly oppoſite to that of alkalies. And if by the addition of any other ſubſtance, that were no more alkalizate than ſea-ſalt, an alkali could be obtained out of ſpirit of nitre of aqua fortis, the producibleneſs of an alkali out of bodies of another nature might be rightly thence inferred: ſo that however it appears, that by the intervention of our experiment, two ſubſtances, that were formerly acid, are turned into one, that is manifeſtly of an alkalizate nature; which is that we would here evince.

Perhaps it may, *Pyrophilus*, be worth while to ſubjoin, that to proſecute the experiment by inverting it, we drew two parts of ſtrong ſpirit of ſalt from one of purified nitre, but did not obſerve the remaining body to be any thing near ſo conſiderably changed as the ſea-ſalt, from which we had drawn the ſpirit of nitre; ſince though the ſpirit of ſalt, that came over, did (as we expected) bring over ſo many of the corpuſcles of the nitre, that being heated, it would readily enough diſſolve foliated gold; yet the ſalt, that remained in the retort, being put upon quick coals, did flaſh away with a vehement and halituous flame, very like that of common nitre.

Experiment VI.

I Come now, *Pyrophilus*, to an experiment, which, though in ſome things it be of kin to that, which I have already taught you concerning the changing of ſea-ſalt by aqua fortis, will yet afford us divers other inſtances, to ſhew, how upon the change of texture in bodies there may ariſe divers new qualities; eſpecially of that ſort, which, becauſe they are chiefly produced by chymiſtry, and are wont to be conſidered by chymiſts, if not by them only, may in ſome ſenſe be called chymical.

THE body, which, partly whilſt we were preparing it, and partly when we had prepared it, afforded us theſe various phænomena, either is the ſame, that *Glauberus* means by his *ſal mirabilis*, or at leaſt ſeems to be very like it: and whether it be the ſame or no, its various and uncommon properties make it very fit to have a place allowed it in this treatiſe; though of the many trials I made with it, I can at preſent find no more among my looſe papers, than that following part of it, that I wrote ſome years ago to an ingenious friend, who I know will not be diſpleaſed, if, to ſave my ſelf ſome time and the trouble of examining my memory, I annex the following tranſcript of it.

[To give you a more particular account of what I writ to you from *Oxford* of my trials about *Glauber*'s ſalt, though I dare not ſay, that I have made the ſelf-ſame thing, which he calls his *ſal mirabilis*, becauſe he has deſcribed it ſo darkly and ambiguouſly, that it is not eaſy to know with any certainty what he means; yet whether or no I have not made ſalt, that, as far as I have yet tried it, agrees well enough with what he delivers of his, and therefore is like to prove either his *ſal mirabilis*, or almoſt as good a one, I ſhall leave you to judge by this ſhort narrative.

THE ſtrange things, that the induſtrious *Glauber*'s writings have invited men to expect from his *ſal mirabilis*, in caſe he be indeed poſſeſſed of ſuch a thing, and the enquiries of divers eminent men, who would fain learn of me what I thought of its reality and nature, invited me, the next opportunity I got, to take into my hands his *Pars altera miraculi mundi*, whoſe title you know promiſes a deſcription of this *ſal artis mirificum*, as he is pleaſed to call it. But, I confeſs, I did not read it near all over, becauſe a great part of it is but a tranſcription of ſeveral intire chapters out of *Paracelſus*, and I perceived, that much of the reſt did, according to the cuſtom of chymical writings, more concern the author than the ſubjects: wherefore looking upon his proceſs of making his *ſal mirabilis*, I ſoon perceived he had no mind to make it common, ſince he only bids us upon two parts of common ſalt diſſolved in common water to pour *A*, without telling us what that *A* is. Wherefore reading on in the ſame proceſs, and finding, that he tells us, that with *B* (which he likewiſe explains not at all, nor determines the quantity of it) one may make an aqua fortis, it preſently called into my mind, that ſome years before having had occaſion to make many trials, mentioned in other tracts of mine, with oil of vitriol and ſalt-petre, I did among other things make a red ſpirit of nitre, by the help only of oil of vitriol: Remembring this, I ſay, I reſorted to one of my *Carneades*'s dialogues *, and reviewing that experiment, as I have ſet it down, I concluded, that though I had not diſſolved the ſalt-petre in water, as *Glauber* doth his common ſalt; yet ſince on the other ſide I made uſe of external fire, it was probable I might this way alſo get a nitrous ſpirit, though not ſo ſtrong. And though by calling the liquor, that muſt make an aqua fortis, *B*; whereas he had called that, which is to

* See the Sceptical Chymiſt.

to make his ſpirit of ſalt and *ſal mirabilis*, *A*, he ſeemed plainly to make them different things; yet relying on the experiment I had made, and putting to a ſolution of nitre as much of the oil of vitriol as I had taken laſt, though that be double the quantity he preſcribes for the making of his *ſal mirabilis*, I obtained out of a low glaſs body and head in ſand an indifferent good *ſpiritus nitri*, that even before rectification would readily enough diſſolve ſilver, though it were diluted with as much of the common water, wherein ſalt-petre had been diſſolved, as amounted at leaſt to double or treble the weight of the nitrous parts. The remaining matter being kept in the fire, till it was dry, afforded us a ſalt eaſily reducible (by ſolution in fair water and coagulation) into cryſtalline grains, of a nature very differing both from crude nitre, and from fixt nitre, and from oil of vitriol. For it coagulated into pretty big and well-ſhaped grains, which, you know, fixed nitre and other alkalizate ſalts are not wont to do; and theſe grains were not, like the cryſtals of ſalt-petre it ſelf, long and hexaëdrical, but of another figure, not eaſy nor neceſſary to be here deſcribed.

BESIDES, this vitriolate nitre (if I may ſo call it) would not eaſily, if at all, flow in the air as fixt nitre is wont to do: moreover, it was eaſily enough fuſible by heat, whereas fixt nitre doth uſually exact a vehement fire for its fuſion: and though crude ſalt-petre alſo melts eaſily, yet to ſatisfy you, how differing a ſubſtance this of ours was from that, we caſt quick coals into the crucible, without being at all able to kindle it. Nay, and when for further trial we threw in ſome ſulphur alſo, though it did flame away it ſelf, yet it did not ſeem to kindle the ſalt, that was hot enough to kindle it; much leſs did it flaſh, as ſulphur is wont on ſuch occaſions to make ſalt-petre do. Add to all this, that a parcel of this white ſubſtance, being without brimſtone made to flow for a while in a crucible with a bit of charcoal for it to work upon, grew manifeſtly and ſtrongly ſcented of ſulphur, and acquired an alkalizate taſte, ſo that it ſeemed almoſt a coal of fire upon the tongue, if it were licked before it imbibed any of the air's moiſture, and (which many perhaps will, though I do not, think ſtranger) obtained alſo a very red colour; which recalled to my mind, that *Glauber* mentions ſuch a change obſervable in his ſalt made of common ſalt, upon whoſe account he is pleaſed to call ſuch a ſubſtance his *Carbunculus*.

BEING invited by this ſucceſs to try, whether I could make his *ſal mirabilis*, notwithſtanding his intimating, as I lately told you, that it is done with a differing menſtruum from that, wherewith the ſalt-petre is to be wrought upon; I obſerved, that where he points at a way of making his ſalt in quantity without breaking the veſſels, he preſcribes, that the materials be diſtilled in veſſels of pure ſilver: whence I conjectured, that it was not aqua fortis or ſpirit of nitre, that he employed to open his ſea-ſalt; and that conſequently, ſince common ſpirit of ſalt was too weak to effect ſo great a change as the experiment requires. it was very probable, that he imployed oil of ſulphur or of vitriol, which will ſcarce at all fret unalloyed ſilver. And however I concluded, that whatſoever the event ſhould prove, it could not but be worth the while to try, what operation ſuch a menſtruum would have upon ſea-ſalt, as I was ſure had ſuch a notable one upon ſalt-petre. And I remember, that formerly making ſome experiments about the differing manners of diſſolution of the ſame concrete by ſeveral liquors, I found, that oil of vitriol diſſolves ſea-ſalt in a very odd way, (which you will find mentioned among my promiſcuous experiments:) wherefore pouring upon a ſolution of bay-ſalt made in but a moderate proportion of water, oil of vitriol to the full weight of the dry ſalt, and abſtracting the liquor in a glaſs cucurbite placed in ſand, I obtain'd, without ſtreſs of fire, beſides phlegm, good ſtore of a liquor, which by the ſmell and taſte ſeemed to be ſpirit of ſalt. And to ſatisfy my ſelf the better, mingling a little of it with ſome of the ſpirit of nitre lately mentioned, I found the mixture, even without the aſſiſtance of heat, to diſſolve crude gold. And having for further trial's ſake poured ſome of it upon ſpirit of fermented urine, till the affuſion ceaſed to produce any conflict, and having afterwards gently evaporated away the ſuperfluous moiſture, there did, as I expected, ſhoot in the remaining liquor a ſalt figured like combs and feathers, thereby diſcloſing it ſelf to be much of the nature of ſal armoniack, ſuch as I elſewhere relate my having made, by mingling ſpirit of urine with ſpirit of common ſalt made the ordinary way.]

THIS, *Pyrophilus*, is all I can find at preſent of that account, of which I hoped to have found much more: but you will be the more unconcerned, for my not adding divers other things, that, I remember, I tried, as well before and after the writing the above tranſcribed paper, (as particularly, that I found the experiment ſometimes to ſucceed not ill, when I diſtilled the oil of vitriol and ſea-ſalt together, without the intervention of water, whereby much time was ſaved, and alſo when I imployed oil of ſulphur, made with a glaſs bell, inſtead of oil of vitriol) if I inform you, that afterwards I found, that *Glauber* himſelf, in ſome of his ſubſequent pieces, had delivered more intelligibly the way of making what he, without altogether ſo great a brag, as moſt think, calls his *ſal mirabilis*, (which yet ſome very ingenious readers of his writings have come to us to teach them) and that thoſe experiments of his about it, which I was able to make ſucceed, (for ſome I was not, and ſome I did not think fit to try) you will find, together with thoſe of my own, in more proper places of other papers. Only, to apply what hath been above related to my preſent purpoſe, I muſt not here pretermit a couple of obſervations.

AND firſt, we may take notice of the power, that mixtures, though they ſeem but very ſlight, and conſiſt of the ſmalleſt number of ingredients, may, if they make great changes of texture,

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texture, have, in altering the nature and qualities of the compounding bodies. For in our (above recited) case, though sea-salt being a body considerably fixed requires a naked fire to be elevated even by the help of copious additaments of beaten bricks or clay, &c. to keep it from fusion, yet the saline corpuscles are distilled over in a moderate fire of sand; whilst the oil of vitriol, by whose intervention they acquire this volatility, though it be not (like the other) a gross, or as the same chemist speaks, corporeal salt, but a liquor, that has been already distilled, is yet by the same operation so fixed, as to stay behind not only in the retort, but, as I have sometimes purposely tried, in much considerabler heats than that needs in this experiment be exposed to. Nor only is the oil of vitriol made thus far fixed, but it is otherwise also no less changed. For when the remaining salt has been exposed to a competent heat, that it may be very dry and white, to be sure of which I several times do, when the distillation is ended, keep the remaining mass (taken out of the retort and beaten) in a crucible among quick coals, you shall have a considerable quantity (perhaps near as much as the sea-salt you first employed) of a substance, which, though not insipid, has not at all the taste of sea-salt, or any other pungent one, and much less the highly corrosive acidity of oil of vitriol.

And the mention of this substance leads me to the second particular I intended to take notice of, which is a phænomenon to confirm what I formerly intimated, that notwithstanding the regular and exquisite figures of some salts, they may, by the addition of other bodies, be brought to constitute crystals of very differing, and yet of curious, shapes. For if you dissolve the hitherto mentioned *caput mortuum* of sea-salt (after you have made it very dry, and freed it from all pungency of taste) in a sufficient quantity of fair water, and having filtrated the solution, suffer the dissolved body leisurely to coagulate, you will probably obtain, as I have often done, crystals of a far greater transparency, than the cubes, wherein sea-salt is wont to shoot, and of a shape far differing from theirs, though oftentimes no less curious than that of those cubes: and, which makes mainly for my present purpose, I have often observed those finely-figured crystals to differ as much in shape from one another, as from the grains of common salt. And indeed I must not on this occasion conceal from you, that whether it be to be imputed to the peculiar nature of sea-salt, or (which I judge much more probable) to the great disparities to be met with in liquors, that do all of them pass for oil of vitriol, whether (I say) it be to this or to some other cause, that the effect is to be imputed, I have found my attempts to make the best sort of *sal mirabilis* subject to so much uncertainty, that though I have divers times succeeded in them, I have found so little uniformity in the success, as made me reckon this experiment amongst contingent ones, and almost weary of meddling with it.

Experiment. VII *.

I Remember, *Pyrophilus*, I once made an experiment, which if I had had the opportunity to repeat, and had done so with the like success, I should be tempted to look upon it, though not as a lucriferous experiment, (for it is the quite contrary) yet as so lucriferous a one, as, how much soever it may serve to recommend chemistry itself, may no less displease envious chemists, who will be troubled, both that one, who admits not their principles, should devise such a thing; and that, having found it, he should not (chemist like) keep it secret.

But to give you a plain and naked account of this matter, that you may be able the better to judge of it, and, if you please, to repeat it, I will freely tell you, that supposing all metals, as well as other bodies, to be made of one catholick matter common to them all, and to differ but in shape, size, motion, or rest, and texture of the small parts they consist of, from which affections of matter the qualities, that difference particular bodies, result, I could not see any impossibility in the nature of the thing, that one kind of metal should be transmuted into another; (that being in effect no more, than that one parcel of the universal matter, wherein all bodies agree, may have a texture produced in it, like the texture of some other parcel of the matter common to them both.)

And having first supposed this, I further considered, that in a certain menstruum, which according to vulgar chemists doctrine, must be a worthless liquor, according to my apprehension, there must be an extraordinary efficacy in reference to gold, not only to dissolve and otherwise alter it, but to injure the very texture of that supposedly immutable metal.

The menstruum then I chose to try, whether it could not dissolve gold with, is made by pouring on the rectified oil of the butter of antimony, as much strong spirit of nitre, as would serve to precipitate out of it all the *bezoarticum minerale*; and then with a good smart fire distilling off all the liquor, that would come over, and (if need be) cohobating it upon the antimonial powder. For though divers chemists, that make this liquor, throw it away, upon presumption, that because of the ebullition, that is made by the affusion of the spirit to the oil and the consequent precipitation of a copious powder, the liquors have mutually destroyed or disarmed each other; yet my notions and experience of the nature of some such mixtures invite me to prize this, and give it the name of *menstruum peracutum*.

Having then provided a sufficient quantity of this liquor, (for I have observed, that

* Though this VIIth experiment, being considerable and very pertinent, the author thought fit to mention it, such as it is here delivered, when he writ but to a private friend; yet after he was induced to publish these papers, it was the (now raging) plague, which drove him from the accommodation requisite to his purpose, that frustrated the design he had of first repeating that part of the experiment, which treats of the destruction of gold: for as for that part, which teaches the volatilization of it, he had tried that often enough before.

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gold ordinarily requires a more copious ſolvent than ſilver,) we took a quantity of the beſt gold we could get, and melted it with three or four times its weight of copper, which metal we chooſe rather than that, which is more uſual among refiners, ſilver, that there may be the leſs ſuſpicion, that there remained any ſilver with the gold after their ſeparation: this mixture we put into good aqua fortis, or ſpirit of nitre, that all the copper being diſſolved, the gold might be left pure and finely powdered at the bottom; this operation with aqua fortis being accounted the beſt way of refining gold, that is yet known, and not ſubject like lead to leave any ſilver with it, ſince the aqua fortis takes up that metal. And for greater ſecurity, we gave the powder to an ancient chemiſt to boil ſome more of the menſtruum upon it, without communicating to him our deſign. This highly refined gold being, by a competent degree of heat, brought, as is uſual, to its native colour and luſtre, we put to it a large proportion of the *menſtruum peracutum*, (to which we have ſometimes found cauſe to add a little ſpirit of ſalt, to promote the ſolution) wherein it diſſolves ſlowly and quietly enough; and there remained at the bottom of the glaſs a pretty quantity (in ſhew, though not in weight) of white powder, that the menſtruum would not touch; and, if I much miſremember not, we found it as indiſſolvable in aqua regis too. The ſolution of gold being abſtracted, and the gold again reduced into a body did, upon a ſecond ſolution, yield more of the white powder, but not (if I remember aright) ſo much as at the firſt: now having ſome little quantity of this powder, it was eaſy with borax or ſome other convenient flux to melt it down into a metal, which metal we found to be white like ſilver, and yielding to the hammer, if not to a leſs preſſure, and ſome of it being diſſolved in aqua fortis, or ſpirit of nitre, did, by the odious bitterneſs it produced, ſufficiently confirm us in our expectation, to find it true ſilver.

I Doubt not but you will demand, *Pyrophilus*, why I did not make other trials with this factitious metal, to ſee in how many other qualities I could verify it to be ſilver: but the quantity I recovered after fuſion was ſo ſmall, ſome of it perhaps being left either in the flux, or in the crucible, that I had not wherewithal to make many trials; and being well enough ſatisfied by the viſible properties and the taſte peculiar to ſilver, both that it was a metal, and rather ſilver than any other, I was willing to keep the reſt of it for a while, as a rarity, before I made further trials with it; but was ſo unfortunate, as with it to loſe it in a little ſilver box, where I had ſomething of more value, and poſſibly of more curioſity.

You will alſo aſk, why I repeated not the experiment? To which I ſhall anſwer, that, beſides that one may eaſily enough fail in making the menſtruum fit for my purpoſe, I did, when I had another opportunity, (for I was long without it) make a ſecond attempt; and having, according to the above mentioned method, brought it ſo far, that there remained nothing but the melting of the white powder into ſilver, when having waſhed it, I had laid it upon a piece of white paper by the fire's ſide to dry, being ſuddenly called out of my chamber, an ignorant maid, that in the mean time came to dreſs it up, unluckily ſwept this paper, as a foul one, into the fire: which diſcouragement, together with a multiplicity of occaſions, have made me ſuſpend the purſuit of this experiment till another opportunity. But in the mean time, I was confirmed in ſome part of my conjecture by theſe things.

The firſt, by finding, that with ſome other menſtruums, which I tried, and even with good aqua regis itſelf, I could obtain from the very beſt gold I diſſolved in them ſome little quantity of ſuch a white powder, as I was ſpeaking of; but in ſo very ſmall a proportion to the diſſolved gold, that I had never enough of it at once to think it worth proſecuting trials with.

The other was this, that a very experienced mineraliſt, whom I had acquainted with part of what I had done, aſſured me, that an eminently learned and judicious perſon, that he named to me, had, by diſſolving gold in a certain kind of aqua regis, and after by reduction of it into a body, re-diſſolving it again, and repeating this operation very often, reduced a very great, if not much the greater part, of an ounce of gold into ſuch a white powder.

And the third thing, that confirmed me, was the proof given me by ſome trials, that I purpoſely made, that the *menſtruum peracutum* I employed had a notable operation upon gold, and would perform ſome things (one of which we ſhall by and by mention) which judicious men, that play the great criticks in chemiſtry, do not think feaſible; ſo that there ſeems no greater cauſe to doubt, that the above-mentioned ſilver was really obtained out of the pure gold, than only this, that men have hitherto ſo often in vain attempted to make a real tranſmutation of metals, (for the better or for the worſe,) and to deſtroy the moſt fixed and compacted body of gold, that the one is looked upon as an unpracticable thing, and the other as an indeſtructible metal.

To reflect then a little upon what we have been relating, if we did not miſtake nor impoſe upon our ſelves, (I ſay upon our ſelves, the project being our own, and purſued without acquainting any body with our aim,) it may afford us very conſiderable conſequences of great moment.

And in the firſt place, it ſeems probably reducible from hence, that however the chemiſts are wont to talk irrationally enough of what they call *tinctura auri*, and *anima auri*; yet, in a ſober ſenſe, ſome ſuch thing may be admitted: I ſay, ſome ſuch thing, becauſe as on the one hand I would not countenance their wild fancies about theſe matters, ſome of them being as unintelligible, as the Peripatetics ſubſtantial forms; ſo, on the other hand, I would not readily deny, but that there may be ſome more noble and ſubtile corpuſcles, that being duly conjoined with the reſt of the matter, whereof gold conſiſts, may qualify that matter

to

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to look yellow, to reſiſt aqua fortis, and to exhibit thoſe other peculiar phænomena, that diſcriminate gold from ſilver; and yet theſe noble parts may either have their texture deſtroyed by a very piercing menſtruum, or by a greater congruity with its corpuſcles, than with thoſe of the remaining part of the gold, may ſtick more cloſe to the former, and by their means be extricated and drawn away from the latter. As when, (to explain my meaning by a groſs example) the corpuſcles of ſulphur and mercury do, by a ſtrict coalition, aſſociate themſelves into the body we call vermilion, though theſe will riſe together in ſublimatory veſſels, without being divorced by the fire, and will act in many caſes, as one phyſical body; yet it is known enough among chymiſts, that if you exquiſitely mix with it a due proportion of ſalt of tartar, the parts of the alkali will aſſociate themſelves more ſtrictly with thoſe of the ſulphur, than theſe were before aſſociated with thoſe of the mercury; whereby you ſhall obtain out of the cinnabar, which ſeemed intenſely red, a real mercury, that will look like fluid ſilver. And this example prompts me to mind you, *Pyrophilus*, that, at the beginning of this paragraph, I ſaid no more, than that the conſequence, I have been deducing, might probably be inferred from the premiſes. For as it is not abſurd to think, that our menſtruum may have a particular operation upon ſome noble, and (if I may ſo call them) ſome tinging parts of the gold, ſo it is not impoſſible, but that the yellowiſhneſs of that rich metal may proceed not from any particular corpuſcles of that colour, but from the texture of the metal; as in our lately-mentioned example, the cinnabar was highly red, though the mercury it conſiſted of, were ſilver-coloured, and the ſulphur but a pale yellow; and conſequently, the whiteneſs and other changes produced in the new metal we obtained, may be attributed, not to the extraction of any tinging particles, but to a change of texture, whereon the colour as well as other properties of the gold did depend. But that, which made me unwilling to reject the way I firſt propoſed of explicating this change of colour, was, that a mineraliſt of great veracity hath ſeveral times aſſured me, that a known perſon in the relator's country, the *Netherlands*, got a great deal of money by the way of extracting a blue tincture out of copper, ſo as to leave the body white; adding, that he himſelf, having procured from a friend (to ſatisfy his curioſity) a little of the menſtruum, (whoſe chief ingredients his friend communicated to him, and he to me) he did, as he was directed, diſſolve copper in common aqua fortis, to reduce it into ſmall parts; and then having kept the calx of the powder of this copper for ſome hours in this menſtruum, he perceived, that the clear liquor, which was weak in taſte, did not diſſolve the body of the metal, but only extract a blue tincture, leaving behind a very white powder, which he quickly reduced by fuſion into a metal of the ſame colour, which he found as malleable as before. Which I the leſs wonder at, becauſe the experienced chymiſt *Johannes Agricola*, in his Dutch annotations upon *Poppius*, mentions the making of a white and malleable copper in good quantities upon his own knowledge; and that of ſuch a kind of copper I have with pleaſure made trial, I elſewhere relate. But of theſe matters we may poſſibly ſay more in a convenient place.

THE ſecond thing, that ſeems deducible from our former narrative, is, that however moſt (for I ſay not all) of the judiciouſeſt among the chymiſts themſelves, as well as among their adverſaries, believe gold too fixed and permanent a body to be changeable by art, inſomuch that it is a received axiom amongſt many eminent Spagyriſts, that *facilius eſt aurum conſtruere, quàm deſtruere*; yet gold itſelf is not abſolutely indeſtructible by art, ſince gold being acknowledged to be an homogeneous metal, a part of it was, by our experiment, really changed into a body, that was either true ſilver, or at leaſt a new kind of metal very different from gold. And ſince it is generally confeſſed, that among all the bodies we are allowed to obſerve near enough, and to try our ſkill upon, there is not any, whoſe form is more ſtrictly united to its matter than that of gold; and ſince alſo the operation, by which the white powder was produced, was made only by a corroſive liquor, without violence of fire; it ſeems at leaſt a very probable inference, that there is not any body of ſo conſtant and durable a nature, but that, notwithſtanding its perſiſting inviolated in the midſt of divers ſenſible diſguiſes, its texture, and conſequently its nature, may be really deſtroyed, in caſe this more powerful and appropriated agent be brought, by a due manner of application, to work upon the body, whoſe texture is to be deſtroyed.

BUT this matter we elſewhere handle, and therefore ſhall now proceed to the laſt and chief conſectaries of our experiment.

THIRDLY then, it ſeems deducible from what we have delivered, that there may be a real tranſmutation of one metal into another, even among the perfecteſt and nobleſt metals, and that effected by factitious agents in a ſhort time, and, if I may ſo ſpeak, after a mechanical manner. I ſpeak not here of projection, whereby one part of an aurifick powder is ſaid to turn I know not how many hundred or thouſand parts of an ignobler metal into ſilver or gold, not only becauſe, though projection includes tranſmutation, yet tranſmutation is not all one with projection, but far eaſier than it: but chiefly becauſe it is not in this diſcourſe you are to expect what I can ſay, and do think, concerning what men call the philoſophers ſtone. To reſtrain my ſelf then to the experiment we are conſidering, that ſeems to teach us, that at leaſt among inanimate bodies, the nobleſt and conſtanteſt ſort of forms are but peculiar contrivances of the matter, and may, by agents, that work but mechanically, that is, by locally moving the parts, and changing their ſizes, ſhape, or texture, be generated and deſtroyed; ſince we ſee, that in the ſame parcel of metalline matter, which a little before was true and

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pure gold, by having ſome few of its parts withdrawn, and the reſt tranſpoſed, or otherwiſe altered in their ſtructure, (for there appears no token, that the menſtruum added any thing to the matter of the produced ſilver) or by both theſe ways together, the form of gold, or that peculiar modification, which made it yellow, indiſſoluble in aqua fortis, *&c.* is aboliſhed; and from the new texture of the ſame matter there ariſes that new form or convention of accidents, from which we call a metal ſilver. And ſince ours was not only diſſoluble in aqua fortis, but exhibited that exceſſively bitter taſte, which is peculiar to ſilver, there ſeems no neceſſity to think, that there needs a diſtinct agent, or a peculiar action of a ſubſtantial form, to produce in a natural body the moſt peculiar and diſcriminating properties. For it was but the ſame menſtruum, devoid of bitterneſs, that by deſtroying the texture of gold changed it into another, upon whoſe account it acquired at once both whiteneſs in colour, diſſolubleneſs in aqua fortis, and aptneſs to compoſe a bitter body with it, and I know not how many other new qualities are attributed.

I Know it is obvious to object, that it is no very thrifty way of tranſmutation, inſtead of exalting ſilver to the condition of gold, to degrade gold to the condition of ſilver. But a tranſmutation is nevertheleſs more or leſs real, for being or not being lucriferous; and ſince that may inrich a brain, that may impoveriſh a purſe, I muſt look upon your humour as that of an alchymiſt, rather than of a philoſopher, if I durſt not expect, that the inſtructiveneſs in ſuch an experiment will ſuffice to recommend it to you. And if I could have ſatisfied my ſelf, that good authors are not miſtaken about what they affirm of the tranſmutation of iron into copper, though, the charge and pains conſidered, it be a matter of no gain, yet I ſhould have thought it an experiment of great worth, as well as the tranſmutation of ſilver into gold. For it is no ſmall matter to remove the bounds, that nature ſeems very ininduſtriouſly to have ſet to the alterations of bodies; eſpecially among thoſe durable and almoſt immortal kinds, in whoſe conſtancy to their firſt forms nature ſeems to have deſigned the ſhewing her ſelf invincible by art.

I Should here, *Pyrophilus*, conclude what I have to ſay of the experiment, that hath already ſo long entertained us, by recommending to you the repetition of what I had not the opportunity to try above once from end to end, were it not, that I remember ſomething I ſaid about the *menſtruum peracutum*, may ſeem to import a promiſe of communicating to you ſomething of the efficacy of that liquor upon gold. And therefore partly for that reaſon, and partly to make ſure, that the preſent diſcourſe ſhall not be uninſtructive to you, I would add, that though not only the generality of refiners and mineraliſts, but divers of the moſt judicious cultivators of chymiſtry it ſelf, hold gold to be ſo fixed a body, that it can as little be volatilized as deſtroyed, and that upon this ground, that the proceſſes of ſubliming or diſtilling gold to be met with in divers chymical books are either myſtical, or unpracticable, or fallacious, (in which opinion I think them not much miſtaken;) though this, I ſay, be the perſuaſion even of ſome critical chymiſts, yet, upon the juſt expectation I had to find my menſtruum very operative upon gold, I attempted and found a way to elevate it to a conſiderable height, by a far leſs proportion of additament, than one, that were not fully perſuaded of the poſſibility of elevating gold, would imagine; and though I have indeed found, by two or three ſeveral liquors, (eſpecially the *aqua pugilum*, enigmatically deſcribed by *Baſilius)* that the fixedneſs of gold is not altogether invincible, yet I found the effect of theſe much inferiour to that of our mixture; touching which I ſhall relate to you the eaſieſt and ſhorteſt, though not perhaps the very beſt, manner of imploying it.

We take then the fineſt gold we can procure, and having either granulated it or laminated it, we diſſolve it in a moderate heat with a ſufficient quantity of the *menſtruum peracutum*, and having carefully decanted the ſolution into a conveniently ſized retort, we very gently in a ſand-furnace diſtil off the menſtruum; and if we have a mind to elevate the more gold, we either pour back upon the remaining ſubſtance the ſame menſtruum, or, which is better, re-diſſolve it with freſh. The liquor being abſtracted, we urge the remaining matter by degrees of fire, and in no ſtronger a one than what may eaſily be given in a ſand-furnace, a conſiderable quantity of the gold will be elevated to the upper part of the retort, and either fall down in a golden-coloured liquor into the receiver, or, which is more uſual, faſten itſelf to the top and neck in the form of a yellow and reddiſh ſublimate; and ſometimes we have had the neck of the retort inriched with good ſtore of large thin cryſtals, not yellow but red, and moſt like rubies, very glorious to behold; (though even theſe being taken out, and ſuffered to lie a due time in the open air, would loſe their ſaline form, and run *per deliquium* into a liquor.) Nor ſee I any cauſe to doubt, but that by the re-affuſions of a freſh menſtruum upon the dry calx of gold, that ſtays behind, the whole body of the metal may be eaſily enough made to paſs through the retort, though for a certain reaſon I forbore to proſecute the experiment ſo far.

But here, *Pyrophilus*, I think my ſelf obliged to interpoſe a caution, as well as to give you a further information about our preſent experiment. For firſt, I muſt tell you, that though even learned chymiſts think it a ſufficient proof of a true tincture, that not only the colour of the concrete will not be ſeparated by diſtillation, but the extracted liquor will paſs over tinged into the receiver; yet this ſuppoſition, though it be not unworthy of able men, may in ſome caſes deceive them. And next I muſt tell you, that whereas I ſcruple not in ſeveral writings of mine to teach, that the particles of ſolid and conſiſtent bodies are not always unfit to help to make up fluid

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fluid ones, I ſhall now venture to ſay further, that even a liquor made by diſtillation, how volatile ſoever ſuch liquors may be thought, may in part conſiſt of corpuſcles of the moſt compact and ponderous bodies in the world.

Now to manifeſt both theſe things, and to ſhew you withal the truth of what I elſewhere teach, *That ſome bodies are of ſo durable a texture, that their minute parts will retain their own nature, notwithſtanding variety of diſguiſes, which may impoſe not only upon other men, but upon chymiſts themſelves*; I will add, that to proſecute the experiment, I dropped into the yellow liquor afforded me by the elevated gold a convenient quantity of clean running mercury, which was immediately coloured with a golden coloured film, and ſhaking it to and fro, till the menſtruum would gild no more, when I ſuppoſed the gold to be all precipitated upon the mercury, I decanted the clarified liquor, and mixing the remaining amalgam (if I may ſo call it) of gold and mercury with ſeveral times its weight of borax, I did as I expected; by melting them in a ſmall crucible, eaſily recovered the ſcattered particles of the elevated metal, reduced into one little maſs or bead of corporal or yellow (though perhaps ſomewhat paliſh) gold. But yet, whether the gold, that tinged the menſtruum, might not, before the metal was reduced or precipitated out of it, have been more ſucceſsfully applied to ſome conſiderable purpoſes than a bare ſolution of gold, that hath never been elevated, may be a queſtion, which I muſt not in this place determine, and ſome other things, that I have tried about our elevated gold, I have elſewhere taken notice of; only this further uſe I ſhall here make of this experiment, that whereas I ſpeak in other papers, as if there may be a volatile gold in ſome ores and other minerals, where the mine-men do not find any thing of that metal, I mention ſuch a thing upon the account of the paſt experiment and ſome analogies. And therefore, as I would not be underſtood to adopt what every chymical writer is pleaſed to fancy concerning volatile gold; ſo I think judicious men, that are not ſo well acquainted with chymical operations, are ſometimes too forward to condemn the chymiſts obſervations; not becauſe their opinions have nothing of truth, but becauſe they have had the ill luck not to be warily enough propoſed. And to give an inſtance in the opinion, that ſome minerals have a volatile gold, (and the like may be ſaid of ſilver) I think I may give an acoount rational enough of my admitting ſuch a thing, by explicating it thus: that as in our experiment, though after the almoſt total abſtraction of the menſtruum, the remaining body being true gold, and conſequently in its own nature fixed, yet it is ſo ſtrictly aſſociated with ſome volatile ſaline particles, that theſe being preſſed by the fire, carry up along with them the corpuſcles of the gold, which may be reduced into a maſs by the admiſtion of borax, or ſome other body fitted to divorce the corpuſcles of the metal from thoſe, that would elevate them, and to unite them into grains, too big and ponderous to be ſublimed: ſo in ſome mineral bodies there may be pretty ſtore of corpuſcles of gold ſo minute, and ſo blended with the unfixed particles, that they will be carried up together with them by ſo vehement a heat, as is wont to be imployed to bring ores, and even metalline maſſes, to fuſion. And yet it is not impoſſible, but that theſe corpuſcles of gold, that in ordinary fuſions fly away, may be detained and recovered by ſome ſuch proper additament, as may either work upon, and (to uſe a chymical term) mortify the other parts of the maſs, without doing ſo upon the gold; or, by aſſociating with the volatile and ignobler minerals ſome way or other, diſable them to carry away the gold with them, as they otherwiſe may do; or by its fixedneſs and cognation of nature make the diſperſed gold imbody with it. On which occaſion I remember, that a very ingenious man deſiring my thoughts upon an experiment, which he and ſome others, that were preſent at it, looked upon as very ſtrange; namely, that ſome good gold having for a certain trial been coupled with a gread deal of lead, inſtead of being advanced in colour, as in goodneſs, was grown manifeſtly paler than before; my conjecture being, that ſo great a proportion of lead might contain divers particles of volatile ſilver, which meeting with the fixed body of the gold by incorporating therewith, was detained, was much confirmed, by finding upon inquiry, that the gold inſtead of loſing its weight, had it conſiderably increaſed; which did much better anſwer my gueſs, than it did their expectation, that made the experiment, and were much ſurpriſed at the event. But this is no fit place to proſecute the conſideration of the additaments, that may be uſed to unite and fix the particles of the nobler metals blended with volatile bodies; though perhaps what hath been ſaid may afford ſome hint about the matter, as well as ſome apology for the chymical term, volatile gold: the poſſibility of which, I preſume, we have evinced by the latter part of this experiment, (in which I am ſorry I cannot remember the proportion of the remaining ſalts, that were able to elevate the gold) for that I have ſeveral times made, and therefore dare much more confidently rely on it, than I can preſs you to do on the former part (about the tranſmutation, or at leaſt deſtruction of gold) till you or I ſhall have opportunity to repeat that trial.

Experiment VIII.

THOUGH, *Pyrophilus*, the experiment I am about to ſubjoin, may at the firſt glance ſeem only to concern the *production of taſtes*, and be indeed one of the principal, that I deviſed concerning that ſubject, and that belongs to the notes I have made about thoſe qualities; yet, if you do not of your ſelf take notice of it, I may hereafter have occaſion to ſhew you, that there are ſome particulars in this experiment, that are applicable to more than taſtes. And ſince I had once thoughts (however ſince diſcouraged by the difficulties of the attempt) to make my notes extend even to divers qualities,

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lities, which the operations of chymiſts and the practice of phyſicians have made men take notice of; (ſuch as the powers of corroding, precipitating, fixing, purging, bliſtering, ſtupifying, &c.) I preſume you will not diſlike that one, who had thoughts to ſay ſomething even of chymical and of medical qualities, if I may ſo call them, ſhould give you here an experiment or two about more obvious, though particular affections of bodies, when there are ſeveral things in the experiment, that may be of a general import to the doctrine of the origin of qualities and forms.

We took then an ounce of refined ſilver, and having diſſolved it in aqua fortis, we ſuffered it to ſhoot into cryſtals, which being dried, we found to exceed the weight of the ſilver by ſeveral drachms, which accrued upon the concoagulation of the acid ſalts, that had diſſolved and were united to the metal. Theſe cryſtals we put into a retort, and diſtilled them in ſand, with almoſt as great a heat as we could give in a hammered iron furnace, wherein the operation was made; but there came over only a very little ſouriſh phlegm with an ill ſcent: wherefore the ſame retort being ſuffered to cool, and then coated, it was removed to another furnace, capable of giving a far higher degree of heat, namely, that of a naked fire, and in this furnace the diſtillation was purſued by the ſeveral degrees of heat, till at length the retort came to be red-hot, and kept ſo for a good while: but though even by this operation there was very little driven over, yet that ſufficiently manifeſted what we aimed at ſhewing, namely, that a body extremely bitter might afford, as well as it conſiſted of, good ſtore of parts, that are not at all bitter, but (which is a very differing taſte) eminently ſour. For our receiver being taken off even when it was cold, the contained ſpirit ſmoked out like rectified aqua fortis, and not only ſmelt and taſted like aqua fortis, to the annoyance of the noſe and tongue; but being poured upon filings of crude copper, it fell immediately to corrode them with violence, making much hiſſing, and ſending up thick fumes, and in a trice produced with the corroded copper a bluiſh colour, like that, which that metal is wont to give in good aqua fortis.

Afterwards we took minium and aqua fortis, and made a ſolution, which being filtred and evaporated, left us a *ſaccharum Saturni* much like the common, made with ſpirit of vinegar. Then taking this ſweet vitriol of lead, (as we elſewhere call it) we endeavoured in the formerly mentioned ſand-furnace to drive it over in a retort; but finding that degree of fire incompetent to force over any thing, ſave a little phlegmatick liquor, we cauſed the retort to be coated and transferred to the other furnace, where being urged with a naked fire, it afforded at length a ſpirit ſomewhat more copious than the ſilver had done. This ſpirit ſmoked in the cold receiver as the other had, and did, like it, rankly ſmell of aqua fortis, and was ſo far from retaining any of the ſweetneſs of the concrete, that had yielded it, that it was offenſively acid, and being poured upon minium, it did with noiſe and bubbles fall upon it, and quickly afforded us a liquor, which being filtred, did, by its ſweetneſs, as well as other proofs, aſſure us, that there would have needed but a gentle evaporation (if we had leiſure to make it) to obtain from it a true ſugar of lead. And it is remarkable, that the concrete, which appeared white before diſtillation, remained, for the moſt part, behind in the retort in the form of a black *caput mortuum*, (ſometimes we have had it in a yellowiſh lump) which was neither at all ſweet, as the vitriol of lead it ſelf had eminently been, nor at all ſour, as the liquor diſtilled from it was in a high degree; but ſeemed rather inſipid, and was indeed but a calx of lead, which the heat of the fire had in part reduced into true and manifeſt lead in the retort it ſelf, as appeared by many grains of ſeveral ſizes, that we met with in the *caput mortuum*; (the reſt of which is eaſily enough reducible by fuſion, with a convenient flux, into malleable lead it ſelf.)

There are ſome phænomena of this experiment, that we may elſewhere have occaſion to take notice of, as particularly, that notwithſtanding ſilver be a body ſo fixed in the fire, that it will (as it is generally known) endure the cupel itſelf, and though in the dried cryſtals of ſilver, the ſalt, that adheres to the ſilver, increaſes the weight of the metal but about a fourth or a third part; yet this ſmall proportion of ſaline corpuſcles was able to carry up ſo much of that almoſt fixedeſt of bodies, that more than once we have had the inſide of the retort, to a great height, ſo covered over with the metalline corpuſcles, that the glaſs ſeemed to be ſilvered over, and could hardly, by long ſcraping, be freed from the copious and cloſely adhering ſublimate.

But the phænomenon, that I chiefly deſire to take notice of at preſent, is this, that not only aqua fortis, being concoagulated with differing bodies, may produce very differing concretes, but the ſame numerical ſaline corpuſcles, that, being aſſociated with thoſe of one metal, had already produced a body eminent in one taſte, may afterwards, being freed from that body, compoſe a liquor eminent for a very differing taſte; and after that too, being combined with the particles of another metal, would with them conſtitute a body of a very eminent taſte, as oppoſite as any one can be to both the other taſtes; and yet theſe ſaline corpuſcles, if, inſtead of this ſecond metal, they ſhould be aſſociated with ſuch a one as that they are driven from, would therewith exhibit again the firſt of the three mentioned taſtes. To prove all this, we took cryſtals of refined ſilver made with aqua fortis, and though theſe cryſtals be, as we often note, ſuperlatively bitter; yet having, by a naked fire extorted from them what ſpirit we could, and found that, as we expected, extremely acid, we put one part of it upon a few filings of ſilver, of which it readily made a ſolution more bitter than gall, and the other part of the diſtilled liquor we poured upon minium. And though whilſt it had been an ingredient of the cryſtals

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tals of ſilver committed to diſtillation, it did with that metal compoſe an exceſſively bitter ſubſtance, yet the ſame particles being looſened from that metal, and aſſociated with thoſe of the lead, did with them conſtitute a ſolution, which by evapouration afforded us a *ſaccharum Saturni*, or a vitriol ſweet as ſugar. And for further confirmation, we varied the experiment, having in a naked fire diſtilled ſome dried *ſaccharum Saturni* made with aqua fortis, the little liquor, that came over, in proportion to the body, that afforded it, was ſo ſtrong a ſpirit of nitre, that for ſeveral hours the receiver was filled with the red fumes; and though the ſmoking liquor were hugely ſharp, yet part of it, being poured upon a piece of its own *caput mortuum*, (in which we perceived not any taſte) did at length (for it wrought but very ſlowly) exhibit ſome little grains of a ſaccharine vitriol; but the other part, being put upon filings of ſilver, fell upon it immediately with noiſe and ſtore of ſmoke, and a while after concoagulated with part of it (which it had diſſolved) into a ſalt excceſſively bitter.

Experiment IX.

THE artificial tranſmutation of bodies being, as the rareſt and difficulteſt production, ſo one of the nobleſt and uſefulleſt effects of human ſkill and power, not only the clear inſtances of it are to be diligently ſought for and prized, but even the probabilities of effecting ſuch an extraordinary change of bodies are not to be neglected; eſpecially if the verſion hoped for, be to be made betwixt bodies of primordial textures, (if I may ſo call them) and ſuch bodies, as by the greatneſs of their bulk, and by their being to be found in moſt of the mixed bodies here below, make a conſiderable part of thoſe, that we men have the moſt immediately to do with. Invited by theſe conſiderations, *Pyrophilus*, I ſhall venture to give you the account of ſome obſervations and trials about the tranſmuting of water into earth, though it be not ſo perfect, as I wiſh, and as I hope by God's bleſſing to make it.

THE firſt occaſion, afforded me to do any thing about this matter, was my being conſulted by a gentleman, (an antient chymiſt, but not at all a philoſopher) who relating to me, how much he had (with the wonted ſucceſs of ſuch attempts) laboured after the grand *Arcana*, complained to me, among other things, that, having occaſion to imploy great quantity of purified rain-water, he obtained from it much leſs than he wiſhed of the ſubſtance, that he looked for, but a great deal of a certain whitiſh excrementitious matter, which he knew not what to make of. This gave me the curioſity firſt to deſire a ſight of it, in caſe he had not thrown it away, (which by good fortune he had not) and then, taking notice of the unexpected plenty, and ſome of the qualities of it, to aſk him ſome queſtions, which were requiſite and ſufficient to perſuade me, that this reſidence came not from accidental foulneſs of the water, nor of the veſſels it was received in. This I afterwards often thought of, and indeed it might juſtly enough awaken ſome ſuſpicions, that the little motes, that have been ſometimes obſerved to appear numerous enough in pure rain-water, whilſt it is diſtilling, might not be meerly accidental, but really produced, as well as exhibited by the action of the fire. I thought it then worth while to proſecute this matter a little farther; and having put a pretty quantity of diſtilled rain-water in a clean glaſs body, and fitted it with a head and a receiver, I ſuffered it to ſtand in a digeſtive furnace, till by the gentle heat thereof, the water was totally abſtracted, and the veſſel left dry: which being taken out of the ſand, I found the bottom of the glaſs all covered over with a white (but not ſo very white) ſubſtance; which being ſcraped off with a knife, appeared to be a fine earth, in which I perceived no manifeſt taſte, and which, in a word, by ſeveral qualities ſeemed to be earth.

THIS encouraged me to rediſtil the rain-water in the ſame glaſs body, whoſe bottom, when the water was all drawn off, afforded me more of the like earth: but though the repetition of the experiment, and my having, for greater caution, tried it all the while in a new glaſs, that had not been imployed before to other uſes, confirmed me much in my conjecture, that unleſs it could be proved, which I think will ſcarce be pretended, that ſo inſipid a liquor as rain-water ſhould, in ſo gentle a heat, diſſolve the moſt cloſe and almoſt indeſtructible body of glaſs it ſelf, (which ſuch corroſive menſtruums as aqua fortis and aqua regis are wont to leave unharmed) the earthy powder, I obtained from already diſtilled rain-water, might be a tranſmutation of ſome parts of the water into that ſubſtance; yet having unhappily loſt part of my powder, and conſumed almoſt all the reſt, (for I kept a little by me, which you may yet ſee) I ſhould, till I had more frequently reiterated my experiments, (which then I had not opportunity to do, though I had thoughts of doing it alſo with ſnow-water, that I had put into chymical glaſſes for that purpoſe, and with liquor of melted hail, which I had likewiſe provided) and thereby alſo obtained ſome more of this virgin earth, (as divers chymiſts would call it) to make farther trials with, have retained greater ſuſpicions, if I had not afterward accidentally fallen into diſcourſe of this matter with a learned phyſician, who had dealt much in rain-water; but he much confirmed me in my conjecture, by aſſuring me, that he had frequently found ſuch a white earth, as I mentioned, in diſtilled rain-water, after he had diſtilled the ſame numerical liquor, (carefully gathered at firſt) I know not how many times one after another; adding, that he did not find (any more than I had done) any cauſe to ſuſpect, that if he had continued to rediſtil the ſame portion of water, it would have yielded him more earth.

BUT the oddneſs of the experiment ſtill keeping me in ſuſpenſe, it was not without much delight, that afterwards mentioning it to a very ingenious perſon, whom without his leave, I think not fit to name, well verſed in chymical matters, and whom I ſuſpected to have,

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have, in order to ſome medicines, long wrought upon rain-water, he readily gave me ſuch an account of his proceedings, as ſeemed to leave little ſcruple about the tranſmutation we have been mentioning: for he ſolemnly affirmed to me, that having obſerved, as I had done, that rain-water would, even after a diſtillation or two, afford a terreſtrial ſubſtance, which may ſometimes be ſeen ſwimming up and down in the limpid liquor, he had the curioſity, being ſettled and at leiſure, to try how long he could obtain this ſubſtance from the water. And accordingly having freed rain-water, carefully collected from its accidental, and as it were feculent earthineſs, which it will depoſite at the firſt ſlow diſtillation, (and which is oftentimes coloured, whereby it may be diſtinguiſhed from the white earth made by tranſmutation) he re-diſtilled it in very clean glaſſes, not only eight or ten times, but near two hundred, without finding that his liquor grew weary of affording him the white earth, but rather that the corpuſcles of it did appear far more numerous, or at leaſt more conſpicuous in the latter diſtillation, than in the former. And when I expreſſed my curioſity to ſee this earth, he readily ſhewed me a pretty quantity of it, and preſented me with ſome, which comparing with what I had remaining of mine, I found to be exceeding like it, ſave that it was more purely white, as having been for the main afforded by rain-water, that had been more frequently rectified. And to compare this welcome powder with that I made myſelf, I tried with this divers things, which I had before tried with my own, and (becauſe the quantity preſented me was leſs inconſiderable) ſome others too. For I obſerved in this new powder, as I had done with my own, that being put into an excellent microſcope, and placed where the ſun-beams might fall upon it, it appeared a white meal, or a heap of corpuſcles ſo exceeding, not to ſay unimaginably ſmall, that in two or three choice microſcopes both I and others had occaſion to admire it: and their extreme littleneſs was much more ſenſibly diſcerned by mingling ſome few grains of ſand amongſt them, which made a mixture, that looked like that of pebble ſtones, and of the fineſt flower. For our earth, even in the microſcope, appeared to conſiſt of as ſmall particles, as the fineſt hair-powder to the naked eye. Nor could we diſcern this duſt to be tranſparent, though, when the ſun ſhined upon it, it appeared in the microſcope to have ſome particles a little gliſtering, which yet appearing but in a glaring light, we were not ſure to be no *deceptio viſûs*.

2. I FOUND, that our white powder being caſt into water, would indeed for a while diſcolour it by ſomewhat whitening it, which is no more than ſpaud will do, and the fine duſt of white marble and other ſtones, whoſe corpuſcles, by reaſon of their minuteneſs, ſwim eaſily for a while in the water; but when it was once ſettled at the bottom, it continued there undiſſolved (for aught I could perceive) for ſome days and nights, as earth would have done.

3. HAVING weighed a quantity of it, and put it into a new clean crucible, with another inverted over it for a cover, I placed it among quick coals, and there kept the crucible red-hot for a pretty while, cauſing the fire afterward to be acuated with a blaſt of a bellows; but taking out the powder, I neither found it melted nor clotted into lumps, nor, when I weighed it again, did I ſee cauſe to conclude, that there was much of it waſted, beſides what ſtuck to the ſides of the crucible and to a little clay, wherewith I had luted on the cover, (and which, to ſhew you that the heat had not been inconſiderable, was in ſeveral places burnt red, by the vehemence of fire:) and when I afterwards kept this powder in an open crucible among glowing coals, neither I, nor one that I employed to aſſiſt me, perceived it at all to ſmoke; and having put a little upon a quick coal, and blown that too, I found that, which I had not blown away, to remain fixed (which ſome bodies will not do) upon quick coals, that will endure the fire in a red-hot crucible.

4. I FOUND this powder to be much heavier in ſpecie, than water; for employing a nice pair of gold ſcales, and a method, that would be too long here to deſcribe, I found, that this powder weighed ſomewhat (though not much) more than twice ſo much common water, as was equal to it in bulk. And leſt ſome corollaries, that ſeem obviouſly contained in the common but groundleſs conceits of the Peripateticks, about the proportions of the elements in denſity, *&c.* ſhould make you expect, that this powder ought to have been much more ponderous, I ſhall add, that having had the curioſity, which I wonder no body ſhould have before me, to examine the gravity of the earth, which ſeems the moſt elementary of any we have, I took ſome ſifted wood-aſhes, which I had cauſed to be three or four times boiled in a plentiful proportion of water, to free them from ſalt, and having put them very dry into common water, I found them but little heavier than our newly mentioned powder, ſurpaſſing in weight water of the ſame bulk but twice, and a little more than a 6th part; (water and it being very little more than as 1 to $2\frac{1}{6}$.) And that you may the leſs doubt of this, I will yet ſubjoin, that examining the ſpecific gravity of (white) glaſs itſelf, I found that compact body to be very little, if at all, more than two times and a half as heavy as water of equal bigneſs to it. So that the gravity of that powder, which, borrowing a chymical term, we have been calling virgin-earth, being added to its fixedneſs and other qualities, it may ſeem no great impropriety of ſpeech to name it earth; at leaſt if by earth we mean not the pure elementary earth of the ſchools, which many of themſelves confeſs not to be found actually ſeparate, but a body dry, cold, ponderous, induring the fire, and, which is the main, irreſoluble by water and fire into other bodies ſpecifically different.

[BUT to return to the guiſe of the powder; when I aſked this learned man, whether he obſerved the glaſs he diſtilled in to have been fretted by the liquor, and whether this loſt of

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its ſubſtance, according as it depoſited more powder, he anſwered me (and he is a perſon of unſuſpected credit) that he found not his glaſs to have been injured by the liquor, and that the water waſted (though he were careful it ſhould not do ſo by evaporation and tranſfuſions) by degrees ſo much, that there remained by his eſtimate but about an eighth part of the firſt quantity. And though for certain reaſons he kept by him the liquor laſt diſtilled, yet he doubted not, but that it might be very nigh totally brought into earth, ſince out of an ounce of diſtilled rain-water he had already obtained near three quarters of an ounce, if not more, of the often mentioned earth.]

THESE ſeveral relations will, I ſuppoſe, perſuade you, *Pyrophilus*, that this experiment is hopeful enough to be well worth your purſuing; if not, that perhaps none but ſuch a ſcrupulous perſon as I, would think the proſecution of it other than ſuperfluous. And if you do acquieſce in what hath been already done, you will, I preſume, think it no mean confirmation of the corpuſcularian principles and hypotheſes. For if, contrary to the opinion, that is ſo much in requeſt among the generality of modern phyſicians and other learned men, that the elements themſelves are tranſmuted into one another, and thoſe ſimple and primitive bodies, which nature is preſumed to have intended to be the ſtable and permanent ingredients of the bodies ſhe compounds here below, may be artificially deſtroyed, and (without the intervention of a ſeminal and plaſtick power) generated or produced: if, I ſay, this may be done, and that by ſuch ſlight means, why may we not think, that the changes and metamorphoſes, that happen in other bodies, which are acknowledged by the moderns to be far more liable to alterations, may proceed from the local motion of the minute or inſenſible parts of matter, and the changes of texture, that may be conſequent, thereunto? Some bold atomiſts would here be determining, by what particular ways this ſtrange tranſmutation of water into earth may be performed; and would perchance particularly tell you, how the continually but ſlowly agitated parts of the water, by their innumerable occurſions, may by degrees rub, and as it were grind themſelves into ſuch ſurfaces, as either to ſtick very cloſe to one another by immediate contact, (as I elſewhere obſerve poliſhed pieces of glaſs to do) or implicate and intangle themſelves together ſo, as to make as it were little knots; which knots (he would add) or the newly mentioned cluſters of coherent particles, being then grown too great and heavy to be ſupported by the water, muſt ſubſide to the bottom in the form of a powder, which by reaſon of the ſame gravity of the moleculæ, and the ſtrict union of the leſſer particles, that compoſe them, obtain an indiſpoſition to diſſolve in water, and to be elevated or diſſipated by the fire; as their inſipidneſs may be accounted for by its being but the ſame with that of the liquor, whence they were made, and their tranſparency by that of the water they were made of, and by the multitude of the little ſurfaces, that belong to ſo fine a powder. But though in favour of ſuch conjectures I could ſomewhat illuſtrate them, partly by applying to this occaſion what I elſewhere obſerve of the reducing of the fluid body of quickſilver, by a bare circulation (which is but a repeated diſtillation) with a proportionable heat, into a real powder, which alſo will not ſo eaſily be raiſed by the fire, as the fluid body, whence by change of texture it was made; and partly by ſubjoining, among other things, how by the conjunction of two diſtilled liquors digeſted together I have obtained good ſtore of an inſipid ſubſtance, that would not melt in water, and that would long enough endure no inconſiderable degree of fire; though, I ſay, by theſe and other ſuch particulars I could make our atomiſt's conjectures leſs improbable, yet the full diſquiſition of ſo difficult a ſubject is too long and intricate to be proper for this place. *

AND therefore, without here examining our atomiſt's explication of this metamorphoſis, we will give him leave for a while to ſuppoſe the tranſmutation itſelf to be real, and thereupon to conſider, whether the hiſtorical part of it do not much diſfavour ſome of the chief doctrines of the chymiſts, and a fundamental one of *Helmont*'s. For if the pureſt water may be turned into earth, it will not be eaſy to make it improbable, that the other ingredients of mixt bodies, which the chymiſts call their hypoſtatical principles, are capable of being tranſmuted into one another, which would overthrow one of the main foundations of their whole philoſophy; and beſides, if out of the ſimpleſt water itſelf a moderate fire can produce a large proportion of earth, that was not formerly præexiſtent in it, how ſhall we be ſure, that in all the analyſes, which the fire makes of mixed bodies, the ſubſtances thereby exhibited are obtained by ſeparation only, without any tranſmutation? As for *Helmont*, it is well enough known, that he makes water to be the material principle of all bodies here below, which he would have to be either water it ſelf, or but water diſguiſed by thoſe forms, which the ſeeds of things have given it. I will not here examine, whether this opinion, if he had reſtrained it to animals and vegetables, might not with ſome reſtriction and limitations be kept from appearing abſurd, ſince my *Eleutherius* hath (though without abſolutely adopting it) elſewhere pleaded for its not being ſo extravagant, as it hath been thought.

BUT whereas *Helmont*'s grand argument from experience is grounded on this, that the alkaheſt doth, as he affirms, by being digeſted with and diſtilled from other tangible bodies, reduce them all at laſt into a liquor no way differing from rain-water, though we ſhould grant the matter of fact, yet the experiment of our powder will warrant me to queſtion their ratiocination. For if all mixed bodies be therefore concluded to be materially from water, becauſe they are by the operation of

* What is here delivered may be for the main verified by what the reader will meet with in the (following) Xth experiment, though that be not it which the author meant.

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the fire and a menſtruum, after having paſſed through divers previous changes, reduced at length into inſipid water; by the ſame way of arguing (and with greater cogency) I might conclude, that all thoſe bodies are materially but diſguiſed earth, ſince without intervention of a ſeminal principle, (for *Helmont* will not allow that title to fire, which he ſtyles the artificial death of things) water itſelf may be turned into earth. Indeed if that acute chymiſt were now alive, and had ſuch an immortal liquor, as he deſcribes his alkaheſt to be, I would gladly put him upon trying whether that menſtruum would reduce our white earth into water. But there being no more probability of that, than that ſuch reproduced water, being juſt what it was before, might be turned into earth again; it may be probably ſaid, that ſince theſe bodies are mutually convertible into one another, (and as to the verſion of water into earth, by a ſeemingly ſlight operation) they are not either of them ingenerable and incorruptible elements, much leſs the ſole matter of all tangible bodies, but only two of the primordial and of the moſt obvious ſchematiſms of that, which is indeed the univerſal matter; which as it comes to have its minute particles aſſociated after this or that manner, may, by a change of their texture and motion, conſtitute with the ſame corpuſcles ſometimes water and ſometimes earth.

But, *Pyrophilus*, to leave theſe reflexions, to return to the bold conjectures, that they are grounded on; though if I had leiſure and indulgence enough, I could, I confeſs, add many things in favour of ſome of thoſe thoughts:* yet I would not have you wonder, that whilſt I was mentioning the many particulars, that ſeem to evince the change of water into earth, I ſhould let fall ſome words, that intimate a diffidence about it. For to diſguiſe nothing unto you, I muſt confeſs, that having in ſpite of an unuſual care unluckily loſt a whole paper of the powder I had made my ſelf, and having unexpectedly been obliged to remove from my furnaces, before I had made half the trials I judged requiſite in ſo nice a caſe, I have not yet laid aſide all my ſcruples.

For 1. I would gladly know, whether the untranſmuted rain-water, by the depoſition of ſo much terreſtrial matter, were grown lighter in ſpecie than before, or ſharp in taſte. Next I would be throughly ſatisfied, (which I confeſs I am not yet, notwithſtanding all that the followers of *Angelus Sala* have confidently enough written) whether and how far inſipid liquors (as rain-water is) may or may not work as menſtruums upon ſtones or earthy bodies: not to queſtion whether the particles of rain-water may not by their mutual attrition, or ſome other action upon one another, be reduced into ſhapes and ſizes fit to compoſe ſuch a menſtruum as the liquor was not before; as in divers plants, that ſeemed to be nouriſhed only with water, the ſap endowed with a ſharp taſte and great penetrancy and activity of parts.

2. It were alſo fit to know, whether the glaſs body, wherein all the diſtillations are made, do loſe of its weight any thing near ſo much as the obtained powder amounts to over and above the decrement of weight, which may be imputed to the action of the heat upon the ſubſtance of the glaſs, in caſe it appear by another glaſs, kept empty in an equal heat, and for the ſame time, that the glaſs loſes by ſuch operations any thing worth reckoning. And it were alſo not impertinent to try, whether the gravity of the obtained powder be the ſame in ſpecie with that of the glaſs, wherein the diſtillations were made: (for that it differed but about a fifth part from the weight of cryſtalline glaſs, I lately mentioned.) Which ſcruple and ſome of the former I might have prevented, if I had had convenient metalline veſſels, wherein to make the diſtillations inſtead of glaſs ones.

3. I could wiſh likewiſe, that it were more demonſtrably determined, what is on all hands taken for granted, (as it appears indeed highly probable) that diſtilled rain-water is a perfectly homogeneous body; which if it be not, divers ſuſpicions might be ſuggeſted about its tranſmutation into earth; and if it be, it will be, as a very ſtrange thing, ſo a matter of very great difficulty to conceive, how a perfectly and exquiſitely homogeneous matter ſhould, without any addition or any ſeminal and plaſtick principle, be brought to afford great ſtore of a matter of much more ſpecifick gravity than it ſelf; ſince we ſee, that no aggregate we can make of bodies, but equiponderant in ſpecie with water, doth by virtue of their convention grow ſpecifically heavier than it.

4. Having had the curioſity to try, whether corroſive liquors would work upon our white powder, I found, that not only good oil of vitriol would corrode it, but ſtrong and dephlegmed ſpirit of ſalt did readily work upon part of it, and that without the aſſiſtance of heat, though not without hiſſing and exciting great ſtore of bubbles; as I have known ſuch menſtruums do, when put upon *Lapis Stellaris* or *Oſſifragus*, or ſome ſuch ſoft ſtone; as if that ſo much defecated rain-water, actuated by heat, had reſolved ſome of the looſer corpuſcles of the ſand or ſtone, that together with ſome ſalts compoſe common glaſs, as I have obſerved in ſome petrifying water, that ſome of the bodies I took up, and which were preſumed to be petrified, were but cruſted over with ſtone, that ſeemed generated but by the ſucceſſive appoſition of ſtony particles, that lying inviſibly mingled with the running water, ſtuck in their paſſage to the conveniently diſpoſed bodies, that lay in the ſtream's way. But yet I muſt not omit, that when I ſuffered this mixture to ſettle, as much of the powder, as ſeemed to be a very great part of it, remained in the lower part of the liquor, as if that had rather fretted than diſſolved it; and that not becauſe the menſtruum was overcharged or glutted, as I found by putting in afterwards ſeveral freſh parcels of powder, which it readily fell

* Of the poſſible ways of turning liquors into conſiſtent bodies, by bending, breaking, twiſting, and by otherwiſe changing the texture of the liquor, ſee more particularly the *Hiſtory of Fluidity and Firmneſs*, publiſhed by the author.

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fell upon, not without noiſe and froth. Nor muſt I forget, that ſometimes I have excited ſuch an ebullition, by pouring the ſame liquors upon the earthy part of wood-aſhes, ſeveral times waſhed in boiling water, (though, I confeſs, I afterwards ſomewhat ſuſpected there might remain ſome little adhering alkali, which might occaſion thoſe bubbles, notwithſtanding that both I and another, whom I alſo invited to taſte it, took the earth to be quite ſaltleſs :) I might, *Pyrophilus*, add, that ſometimes alſo methought I found this powder (which yet likewiſe ſometimes happened to me with the lately mentioned earth of wood-aſhes) ſomewhat gritty between my teeth, and ſubjoin divers other particulars, if it were not too tedious to mention to you all the doubts and conſiderations, that have occurred to me about the recited change of water into earth : which yet are not ſuch as ought to hinder me from giving you the hiſtorical account I have ſet down, ſince to ſome of my ſcruples I could here give plauſible anſwers, but that I cannot do it in few words. And if any part of our white powder prove to be true earth, no body perhaps yet knows to what the experiment may lead ſagacious men: and whether in a ſtrict ſenſe it be true earth or no, yet the phænomena, that are exhibited in the production of it, are ſufficient to give this ninth experiment a place among the others (of the ſame decad) with which it is aſſociated. For ſince out of a ſubſtance, that is univerſally acknowledged to be elementary and homogeneous, and which manifeſtly is fluid, tranſparent, much lighter in ſpecie than earth, moiſt and fugitive, there is artificially generated or obtained a ſubſtance conſiſtent, white, and conſequently opacous, comparatively ponderous, dry, and not at all fugitive ; the alteration is ſo great, and effected in ſo ſimple a way, that it cannot but afford us a conſiderable inſtance of what the varied texture of the minute parts may perform in a matter confeſſedly ſimilar. And if frequently diſtilled rain-water ſhould not be allowed homogeneous, our experiment will at leaſt ſhew us, better than perhaps any hath yet done, how little we are bound to believe what the chymiſts and others tell us, when they pretend manifeſtly to exhibit to us homogeneous principles, and elementary bodies; and how difficult it is to be certain, when a body is abſolutely irreſoluble into ſpecifically differing ſubſtances, and conſequently what is the determinate number of the perfectly ſimple ingredients of bodies: (ſuppoſing that ſuch there are.) Though I muſt confeſs, that my only aim is not to relate what hath been done, but to procure the proſecution of it. For if the obtained ſubſtance be, by the rain-water, diſſolved out of the glaſs, this will both prove a noble and ſurprizing inſtance of what may be done by inſipid menſtruums, even upon bodies, that are juſtly reckoned among the compacteſt and moſt indiſſoluble that we know of, and may afford us many other conſiderable hints, that have been partly intimated already : and if, on the other ſide, this powder, whether it be true elementary earth or not, be found to be really produced out of the water it ſelf, it may prove a *magnale* in nature, and of greater conſequence than will be preſently foreſeen, and may make the alchymiſts hopes of turning other metals into gold appear leſs wild ; ſince that by experimentally evincing, that two ſuch difficult qualities to be introduced into a body, as conſiderable degrees of fixity and weight, (whoſe requiſiteneſs to the making of gold are two of the principal things, that have kept me from eaſily expecting to find the attempts of alchymiſts ſucceſsful) may, without the mixture of the homogeneous matter, be generated in it, by varying the texture of its parts.

I WILL not now adventure to add any thing of what I have been attempting about the tranſmuting (without additaments) of pure alkalizate ſalts into earth, becauſe I do not yet know, whether the trials will anſwer my hopes, (for I do not yet call them my expectations.) But upon this ſubject of tranſmutations, I could, if it did not properly belong to another treatiſe, tell you ſomething about the changes, that may be wrought upon highly rectified ſpirit of wine, which would perchance make you think of other things of the like kind leſs infeaſible. For whereas it is a known thing, that that ſpirituous liquor being kindled, (and that, if you pleaſe, by other ſpirit of wine actually fired) will, for aught appears, burn all away, that is, be totally turned into flame; if I durſt rely in ſo important a caſe on a couple of trials, whilſt I hope for an opportunity of making farther ones, I would tell you, that by a way unthought on (that I know of) by any body, I have without any addition obtained from ſuch ſpirit of wine, as being kindled in a ſpoon would flame all away, without leaving the leaſt drop behind it, a conſiderable quantity of downright incombuſtible phlegm. And by another way (mentioned indeed by *Helmont*, but not taught to almoſt any of his readers) ſome ingenious perſons, that you know and eſteem, working by my directions, (but without knowing what each other was doing) did both of them reduce conſiderable quantities of high rectified ſpirit of wine (that would before have burnt all away) into a liquor, that was for the moſt part phlegm, as I was informed as well by my own taſte, as by the trials I ordered to be made : (being forced my ſelf to be moſt commonly abſent.) From which change of the greateſt part of that firſt liquid ſpirit into phlegm, it ſeems deducible, that the ſame portion of matter, which by being kindled may be turned all into fire, may be, by another way of handling, turned into phlegm or water, and this without the addition of any thing, and without being wrought upon by any viſible body, but one ſo extremely dry as duely prepared ſalt of tartar ; and that it ſelf is not ſo indiſpenſably neceſſary to the obtaining of phlegm out of totally inflammable ſpirit of wine, but that, as I was ſaying, I did by another way obtain that dull liquor, without imploying the ſalt or any other viſible body whatſoever. But I make a ſcruple to entertain you any longer with extravagancies of this

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this nature, and yet if I were ſure you would contain your ſmiles, I would add for concluſion, that if I had had time and opportunity to furniſh my ſelf with any quantity of that water, I had it in my thoughts to try, whether that would have afforded me ſuch a terreſtrial ſubſtance as rain-water had done, and thereby have undergone a new and further metamorphoſis.

Experiment X.

THERE is one experiment more, two of the chief phænomena of which belong to another diſcourſe, (where I particularly mention them;) and yet I ſhall conclude this little treatiſe with the recitation of the experiment it ſelf, not only becauſe divers of the phænomena do eminently belong to our preſent ſubject; but becauſe I have ſcarce met with any experiments more ſuitable to the deſign I have of ſhewing, before I conclude this diſcourſe, what great and ſudden productions and deſtructions of qualities may be effected by the compoſition of the ſmalleſt number of ingredients, even among liquors themſelves; and ſuch too, as are believed to be both of them ſimple and homogeneous, and incapable of putrefaction; that ſo it may appear what notable alterations of qualities even ſeemingly ſlight and eaſy mixtures can perform among bodies both of them fluid, as well as among thoſe, that were either both of them ſtable, or one of them ſtable, and the other conſiſtent.

TAKE then of good oil of vitriol and of ſpirit of wine, that will burn all away, equal parts, not in quantity, but in weight; put them together by little and little, and having placed the mixture in a bolt-head or glaſs-egg with a long neck, and carefully ſtopped it with a cork and hard wax, ſet the veſſel in a moderate heat, to digeſt for a competent while, (two or three weeks may do well) then pour out the mixture into a tall glaſs cucurbite, to which lute on a head and a receiver with extraordinary care, to prevent the avolation of the ſpirits, which will be very ſubtile: then with a very gentle fire abſtract the ſpirit of wine, that will firſt aſcend; and when the drops begin to come over ſouriſh, ſhift the receiver, and continue the diſtillation with great care, that the matter boil not over: and when you judge, that about half the acid liquor is come over, it will not be amiſs, though it be not neceſſary, to change the receiver once more: but whether you do this or no, your diſtillation muſt be continued, increaſing the fire towards the latter end, till you have brought over all you can, and what remains in the cucurbite muſt be put into a glaſs well ſtopped to keep it from the air.

N. B. 1. That to the production of moſt, if not of all the phænomena of this experiment, it is not abſolutely neceſſary, that ſo long a digeſtion (not to ſay, not any) be premiſed; though if the time above preſcribed be allowed, the experiment will ſucceed the better.

2. THAT, I remember, I have ſometimes made uſe of oil of ſulphur *per campanam* (as they call it) inſtead of oil of vitriol, to produce the recited phænomena; and though the attempt ſucceeded not ill as to divers particulars, yet I afterwards choſe rather to employ oil of vitriol; both becauſe it did in ſome points better anſwer my expectation than the other liquor, and becauſe I would not give occaſion to ſuſpect, that the odours, hereafter to be mentioned as phænomena of our experiment, were due to the common ſulphur, whence the unctuous liquor made *per campanam* was obtained, as ſuch, and did no way proceed from the acid vitriolate ſalt, which that oil (as it is improperly called) doth abound with.

3. THAT I had likewiſe the curioſity to digeſt oil of vitriol with Spaniſh wine inſtead of ſpirit of wine, by which means I obtained an odd ſpirit and reſidence, and ſome other phænomena, which I content my ſelf to have in this place given hint of, in regard that wine being a liquor of a much leſs ſimple nature than its ſpirit, the phænomena, afforded me by this, are much fitter for my preſent purpoſe.

4. THAT great care muſt be had in regulating the fire, when once a good part of the acid ſpirit mentioned in the proceſs is come over. For if the fire be not increaſed, the reſt will ſcarce aſcend; and if it be increaſed but a little too much, the matter will be more apt, than one would ſuſpect, to ſwell exceedingly in the cucurbite, and perhaps run over into the receiver, and ſpoil what it finds there, as it hath more than once happened to me, when I was fain to commit the management of the fire to others.

NOW the oil of vitriol and the ſpirit of wine being both of them diſtilled liquors, and the latter of them ſeveral times rediſtilled, and one of them being drawn from ſo ſimple and familiar a ſubſtance as wine, and the other from a concrete not more compounded than what nature her ſelf (which, as I elſewhere ſhew, can without the help of art produce vitriol) doth divers times preſent us with; theſe liquors, I ſay, being both of them diſtilled, and conſequently volatile, one would expect, that by diſtilling them they ſhould be brought over united, as I have tried, that the ſpirit of wine and of nitre, or alſo of common ſalt may be; and as the ſpirits of differing vegetables are wont to be; or that at leaſt the diſtillation ſhould not much alter them from what it found them, after they had been well mingled together. But this notwithſtanding, theſe two liquors being of very odd textures in reference to each other, their conjunction and diſtillation will make them exhibit divers conſiderable and perhaps ſurprizing phænomena.

FOR firſt, whereas ſpirit of wine has no great ſcent, nor no good one, and moderately dephlegmed oil of vitriol is wont to be inodorous; the ſpirit, that firſt comes over from our mixture, hath a ſcent not only very differing from ſpirit of wine, but from all things elſe, that I remember I ever ſmelt. And as this new odour doth to almoſt all thoſe, whoſe opinions I have aſked about it, ſeem very fragrant and pleaſant, ſo I have ſometimes had it ſo exceeding ſubtile, that in ſpite of the care, that was taken to lute the glaſſes exactly together, it would perfume the neighbouring parts of

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the laboratory, and would not afterwards be kept in by a close cork, covered with two or three several bladders, but smell strongly at some distance from the phial wherein it was put. I did not think it unlikely, that so noble and piercing a liquor might be of no mean efficacy in physick; and though I missed of receiving an account of its effects from some ingenious physicians, into whose hands I put it to have trials made of it, yet I cannot despair of finding it a considerable medicine, when I remember, partly what hath been done by some acquaintances of mine with bare phlegm of vitriol, upon the account (as is supposed) of that little sulphur of vitriol, that, though but sparingly, doth enrich that liquor; and partly, what the masters of chymical arcana tell us of the wonderful virtues of the volatile sulphur of vitriol, and what I have observed my self, that may invite me to have a good opinion of remedies of that nature.

2. BUT to shew, how much the odours of bodies depend upon their texture, I shall now add, that after this volatile and odoriferous spirit is come over, and has been followed by an acid spirit, it will usually towards the latter end of the distillation be succeeded by a liquor, that is not only not fragrant, but stinks so strongly of brimstone, that I have sometimes known it almost take away the breath (as they speak) of those, who, when I had the receiver newly taken off in my hand, did (either because to make sport I gave them no warning, or because they would not take it, as thinking what I told them was impossible) too boldly adventure their noses in the trial.

3. THERE is in this operation produced a liquor, that will not mingle either with the fragrant, or with the fetid spirit hitherto described, but is very differing from both of them, and is so very pleasant, subtile, and aromatical, that it is no less differing as well from spirit of wine as oil of vitriol. But of this liquor I give a further account in a more convenient place.

4. WHEN the distillation is carried on far enough, you will find at the bottom, that the two above-mentioned diaphanous spirits (for oil of vitriol is indeed rather a saline spirit than an oil) have produced a pretty quantity of a substance, not only very opacous, but black almost like pitch or jet.

5. AND this substance, though produced by two bodies, that were not only fluid but distilled, will not alone be consistent, but (if the distillation have been urged far enough) brittle.

6. AND though spirit of wine be reputed the most inflammable, and oil of vitriol the most corrosive liquor that is known, yet I could not find, that this black substance would easily, if at all, be brought, I say not to flame, but to burn, nor that it had any discernible taste; though both the liquors, from whose mixture it was obtained, have an exceeding strong and pungent taste.

7. AND whereas both oil of vitriol and spirit of wine will each of them more readily, than most liquors, that are yet known, mingle with common water, and diffuse it self therein, I observed, that this pitchy mass, if the distillation had been continued till it was perfectly dry, would not, that I could perceive, dissolve in common water for very many hours, and, if I much misremember not, for some days.

8. AND lastly, whereas the oil of vitriol and the spirit of wine were both of them distilled liquors, and one of them exceeding volatile and fugitive; yet the black mass produced by them was so far fixed, that I could not make it rise by a considerably strong and lasting fire, that would have raised a much more sluggish body than the heaviest of those, that concurred to produce it.

THE remaining particulars, that I have observed in this experiment, belong to another treatise, and therefore I shall forbear to mention them in this: nor shall I at present add any new phænomena to those I have already recited; those freshly mentioned experiments, and those that preceded them being, even without the assistance of the four observations I have delivered before them, sufficient to manifest the truth I have been endeavouring to make out. For in the experiments we are speaking of, it cannot well be pretended, or at least not well proved, that any substantial forms are the causes of the effects I have recited. For in most of the (above-mentioned) cases, besides that in the bodies we imployed, the seminal virtues, if they had any before, may be supposed to have been destroyed by the fire, they were such, as those I argue with would account to be factitious bodies, artificially produced by chymical operations. And it is not more manifest, that in the production of these effects there inter venes a local motion and change of texture by these operations, than it is evident and precarious, that they are the effects of such things, as the schools fancy substantial forms to be: since it is in these new experiments, by the addition of some new particles of matter, or the recess or expulsion of some præ-existent ones, or, which is the most frequent way, by the transposition of minute parts, yet without quite excluding the other two, that no more skilful a chymist than I have been able to produce by art a not inconsiderable number of such changes of qualities, that more notable ones are not ordinarily presented us by nature, where she is presumed to work by the help of substantial forms: I see not, why it may, not be thought probable, that the same catholick and fertile principles, motion, bulk, shape, and texture of the minute parts of matter, may, under the guidance of nature, (whose laws the modern Peripateticks acknowledge to be established by the all-wise God) suffice likewise to produce those other qualities of natural bodies, of which we have not given particular instances.

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FREE CONSIDERATIONS

ABOUT

SUBORDINATE FORMS,

As they are wont to be maintained by divers Learned Moderns.

An Advertiſement.

THE following diſcourſe about ſubordinate forms had come forth the laſt year, annexed to the foregoing examen of ſubſtantial forms, as a part of, or an appendix to it, being then written, and promiſed in the preface to the reader, if by reaſon of the bookſeller's haſte, who was deſirous the book might be printed and publiſhed at the beginning of the term, it had not been left out, and is here added in this ſecond edition, wherein no other addition is made.

THE generality of vulgar philoſophers have for many ages ſo handled the doctrine of forms, as if they ſuſpected not, that more than one form could belong to a natural body: but ſome later writers, eſpecially the learned *Sennertus*, and, if you will believe him, the famous Peripatetick *Zabarel* himſelf, have endeavoured to introduce an hypotheſis, which teaches, that in animals and plants, beſides the ſpecifick form, as *Sennertus* calls it, which alone is wont to be taken notice of, there may reſide in thoſe bodies, and eſpecially in ſome determinate parts of them, certain other forms proper to thoſe parts, but nevertheleſs ſo ſubjected to the predominant miſtreſs form, if I may ſo call it, that they deſerve the title but of ſubordinate forms, and during the reign of the ſpecifick form, are ſubſervient to it, but in the capacity (as it were) of matter; yet ſo that when the ſpecifick form comes to be aboliſhed or depoſed, theſe ſubordinate forms may come to ſet up for themſelves, and in reference to thoſe parts of matter they belong to, exerciſe the functions of ſpecifick forms: as in a dog or a horſe, beſides the ſenſitive ſoul, which is the ſpecifick form of the whole beaſt, the fleſh and blood and bones have their diſtinct forms, which appertain to them as they are ſuch bodies, though they are ruled and imployed by the ſoul, but as the matter which ſhe animates and informs; and when by death the ſenſitive ſoul or ſpecifick form is depoſed or aboliſhed, the body is not preſently reſolved into the four elements, much leſs reduced into the firſt matter, but thoſe ſubordinate forms do ſtill keep the fleſh, fleſh; and the bone, bone; the one for a little, and the other for a much longer time.

TO make out this doctrine, he ingeniouſly urges the ſpecifick virtues obſervable in gathered plants, and particularly the purgative faculty of rhubarb, ſenna, and other cathartick vegetables. And though, as to this noble ſort of examples afforded him by the ſpecifick properties they are endowed with, when they are deprived of the life they enjoyed as plants, it may not be pretended by the obſtinate, that, for aught has been yet tried, rhubarb, ſenna, *&c.* are not purgative, while they are living plants, and ſo, when they are dead, do not ſo much retain as require that ſpecifick virtue; as wine obtains divers medicable virtues (as that of cooling, diſſolving coral, pearl, *&c.*) when (by ſome alteration imperceptible to ſight) loſing its predominant form it turns to vinegar, which it had not before; yet it were not difficult to propoſe experiments, that would determine this ſcruple, if it were thought important enough. And I ſhall add, that it is evident, that damaſk-roſes, for inſtance, which are purgative, retain for a conſiderable time the ſame colour, and fragrant odour, *&c.* when they are gathered, and conſequently acknowledged to be deprived of life, as when they grew upon the tree.

THIS doctrine of ſubordinate forms has been ſo well entertained, and ſuppoſed to be of ſuch importance, and (which nearly concerns the paſt diſcourſe) to afford ſuch countenance to ſubſtantial forms, that the nature of our preſent diſcourſe forbids me to leave it altogether untouched; and the rather, becauſe I have not found it ſo much as taken notice of by the corpuſcularian philoſophers. But as (on the one hand) this conſideration invites me to offer ſomething about this matter, ſo (on the other ſide) joining with the difficulty and abſtruſeneſs of the ſubject, it would deter a bolder writer than I, to pretend to give a full and ſatisfactory account of ſo perplexed and abſtruſe a matter. And therefore I ſhall think my attempt may be excuſable (if not acceptable) if I can at preſent ſhow, that ſubordinate forms may be intelligibly explicated in a general way, according to the corpuſcularian principles, or are at leaſt very reconcileable thereunto. And in regard, that, as I juſt now intimated, the patrons of theſe ſubjugated forms aſſert ſubſtantial ones, and proceed upon other notions that we do not admit, I muſt venture to explicate this matter in a way very differing from theirs. And it will not be amiſs to begin my diſcourſe with laying down ſome obſervations, which may ſerve partly to add ſome things unmentioned to thoſe, that are mentioned by *Sennertus*, or *Zabarel*, towards clearing up the no-

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tion and nature of ſubordinate forms (a ſubject not obvious, not eaſy to be made plain) and partly to make way for the carrying on the ſubſequent part of the diſcourſe, without thoſe excurſions, that would elſe too much interrupt it.

FIRST then, we may conſider, that according to what I have formerly diſcourſed, the name form is a technical word or term of art, whoſe ſignification, as I there alſo noted, is not ſo well defined as is preſumed, and were to be wiſhed. But without much injury to the more obvious and uſual notion of it, we may obſerve, that it is commonly ſome one conſiderable thing (or at moſt, ſome few things) ſuch, for the moſt part, as ſome conſpicuous phænomenon, that is exhibited, or ſome peculiar operation, that is performed by it, or ſome particular uſe, to which it is applicable, upon whoſe account this or that form is attributed to this or that natural body; and only upon the receſs or abolition of which, it is ſaid to loſe its form, or, if you pleaſe, denomination.

SECONDLY, I conſider, that the bodies, whoſe being or not being endowed with ſubordinate forms is contended for, are generally either vegetables, or animals, or bodies belonging to them; and conſequently, theſe bodies being of a very compounded nature, conſiſt of parts whether organical or not, that are not all of them of the ſame nature, which I take to be true, not only of thoſe parts, that are unanimouſly to be organical, but of many of thoſe, that are reputed ſimilar, becauſe as to ſenſe they are ſo. This is evident in bones, which, though believed to have as good a right as any to the title of ſimilar parts, do yet by diſtillation afford ſalt, oil, phlegm, ſpirit, and aſhes. And vitriol, though ſimilar as to ſenſe, may be (as we formerly noted,) artificially produced by uniting the metalline particles of iron or copper with the ſaline corpuſcles of diſtilled ſalt or nitre. Which inſtance I the leſs ſcruple to make uſe of, becauſe, that though the patrons of ſubordinate forms ſeem to have aſſerted them, to give ſome account of what happens in vegetables and animals, when the ultimate form is aboliſhed or expelled; yet for my own part I ſee not, why we may not alſo attribute ſubordinate forms to divers inanimate bodies. To illuſtrate this matter, I will borrow an example from rhubarb, (for this drug, as it is ſold in the ſhops, is an inanimate body) wherein the purgative faculty is affirmed to proceed from a ſubſtantial form; which virtue, whilſt the rhubarb grew in the ground, did, as they teach us, proceed from the ſpecifick form. For if from the ſame rhubarb we do, by a convenient menſtruum, extract together with the finer parts of the body all the purgative virtue, (which, as *Sennertus* himſelf teaches, may very well be done) I ſee not why, according to his grounds, the remaining rhubarb, which will retain divers of its former qualities, if not diſcloſe ſome new ones, ought not to have a peculiar form diſtinct from that which he and the ſchools call *Forma miſtionis* aſſigned to it; to which thoſe qualities may be attributed, and which conſequently may be looked upon as a ſubordinate form in reference to that, which the intire, though inanimate rhubarb, had before. But whatever become of this inſtance, there are other bodies, wherein I ſee not why, according to his grounds, a ſubordinate form may not be allowed. For in an olive or an almond (for example) though when it is gathered it ceaſes to be animated by the vegetative ſoul of the tree, yet it retains the ſame ſhape, colour, *&c.* that it had before it was gathered, (which it retains upon the account of the ſubordinate form, that belonged to it as ſuch a fruit) by virtue of which form it may be preſerved ſound during a whole year, or perhaps much longer; ſo when by barely cruſhing the pulp of the olive between your fingers you may immediately ſqueeze out oil, which confeſſedly was pre-exiſtent there (the preſſure only aſſociating ſo many parts as to make them viſible) and which is a peculiar liquor endowed with noble qualities, and capable of preſerving itſelf divers years: I ſee not, (I ſay) why the form of this oil, from whence its qualities muſt be ſaid to flow, may not be looked upon as having been, whilſt the liquor made a part of the olive, a ſubordinate form to that of the intire fruit; whoſe remaining part having alſo its own peculiar qualities, and that ſuch, whereby, for inſtance, an olive that has loſt its oil much differs from an almond that has loſt its alſo, may, for aught I ſee, deſerve to have a diſtinct ſubordinate form aſcribed unto it. But to make this out the better, I ſhall here add a couple of examples, that perhaps will ſeem clear enough; the one is ſulphur vive, wherein (to ſpeak according to the chymical notions) nature has united under one form two bodies of very differing kinds, the one readily inflammable, and the other a great reſiſter of fire; and yet theſe two are eaſily ſeparable, as may appear by the known chymical practice of kindling ſulphur under a glaſs bell. For the oleaginous part (as the combuſtible is ſuppoſed) manifeſtly burns away with a blue flame, and the ſaline corpuſcles meeting with the moiſt vapours, that are commonly interſperſed in the air, are condenſed againſt the ſides of the glaſs into a highly ſharp and corroſive menſtruum: (which may ſeveral ways be brought to exhibit its ſalt in a dry and brittle form.) The other inſtance I was to mention, is alſo of a body, that cannot be pretended to be factitious, (namely, *cinnabaris foſſilis*,) for in this concrete under the form of a mineral ſtone, nature has ranged three (if not more) compleat bodies, that has each of them its own diſtinct form, and that exceeding different from the others; as may appear when theſe bodies are ſkillfully ſeparated. For thence, as we noted above, we have obtained a running mercury, an inflammable ſulphur, which itſelf will be eaſily allowed to be a compounded body, and a ſtrange concrete, whoſe properties I had not occaſion to look into. To theſe inſtances I might add divers others, if it were neceſſary ſo to do. And if it be ſaid, that theſe forms are not ſubordinate, but rather co-ordinate, it will lie upon the objectors to prove it; who perhaps will find it no eaſy matter to evince, that the ſame ingredient, for inſtance of

of ſulphur, is not as much ſubjugated by the form of the intire body, as that of the purgative portion of rhubarb, by the form of that drug. But if it did appear, that theſe forms were more properly ſtyled co-ordinate than ſubordinate, it would not much trouble me, who am inclined to think, that divers of the forms which *Sennertus* and his followers call ſubordinate or ſubjugated, may be as fitly ſtyled coordinate or concurrent; ſince I ſhall ſhow anon, that I do not aſcribe to the ſpecifick, or ſupreme form in reference to the reſt, ſuch a coercive power and dominion, as thoſe learned men are pleaſed to do.

THIRDLY, I conſider, that all theſe differing bodies, whereof, as of parts, or as of ingredients, a compounded body is made up, are by virtue of the compoſition and peculiar fabrick thereof ſo put together or contrived, that they concur to thoſe actions or operations which are proper to the body as ſuch, and therefore are preſumed to flow immediately from the form of it. For an inſtance of which I ſhall name gunpowder, where three ingredients upon a very ſlight mixture (as I ſhall anon ſhew theirs to be) do by a concurrent action produce thoſe wonderful effects, that are ſcarce to be matched by nature herſelf. And that theſe ſtupendous operations really reſult from the proportion of the ingredients, and the manner of their commixture, will be hereafter manifeſt.

FOURTHLY, I conſider, that notwithſtanding theſe ſeveral parts, whereof the compounded body conſiſts, do in the proper, and, if I may ſo call them, ſpecifick actions of the body ſo concur, as to perform them jointly, and (as the ſchools in divers caſes expreſs themſelves) *per modum unius:* yet theſe thus conſpiring bodies may each of them retain thoſe attributes or that modification, which made it a diſtinct natural body, before it came to be aſſociated with thoſe others, with which it makes up a more compounded body.

AND if it be proper to propoſe here an argument *ad hominem*, I ſhall add, that the more conſiderate of the modern ſchool-men themſelves do, though perhaps unawares, teach ſuch things, as do very well agree with the doctrine of ſubordinate forms. For when in the generation of man they tell us, that, as *Ariſtotle* alſo obſerves, the embryo lives the life of a plant and of an animal, before he attains to live the life of a man, it is plain, that, according to them, upon the introduction of the rational ſoul the vegetative and ſenſitive ſouls, that before ſucceſſively informed the embryo, do ſo no more, the advenient human ſoul becoming now the true form of the human body. And theſe preexiſtent ſouls are not aboliſhed, and do not loſe their being, but only their office, which at firſt was to inform the body of the embryo, but now ceaſes, ſo that they are not deſtroyed, but only depoſed. And this conſideration ſeems to afford ground enough to admit in divers natural bodies forms, that diſpoſe the matter they modify for the reception of a noble ſtamp, for which reaſon I ſometimes call them preparatory forms, beſides thoſe more noted forms, that the ſchools uſually term ſpecifick, (and which I ſometimes call predominant or ſupreme) by which I ſuppoſe is meant (to ſpeak intelligibly) the laſt and higheſt ſtamp, or modification, that nature gives that parcel of matter; whereas the preparatory form is but (if I may ſo ſpeak) a harbinger, that diſpoſes the matter to receive a more perfect form, which, if it be not to be ſucceeded by any other more noble, is intitled the ſpecifick form of that body; as in the embryo the vegetative and the ſenſitive ſoul is but preparatory to the rational, which alone is ſaid to be the ſpecifick form of man.

BUT here I would not be thought to adopt for mine all thoſe opinions, upon which I think it allowable for me to argue with thoſe, that own them. For I muſt not omit to intimate *in tranſitu*, that I elſewhere conſider with what congruity to ſome other of their tenets they can aſſert, and in what ſenſe, in regard of the nature of the thing itſelf, we may admit, that the ſouls of all living creatures be the true forms of their bodies, notwithſtanding the ſcruples ſuggeſted to me, as by other things, ſo particularly by the great difference I take notice of by ſome of theſe animating forms (if I may ſo call them) and other natural forms in reference to the manner of their informing the reſpective bodies they belong to: of this to give an inſtance, it is evident, that the reaſonable ſoul, (which ſome call *animus*, to diſtinguiſh it from the *anima* or ſenſitive) is not the architect of the human body (which they confeſs and teach muſt be organized, before it be fit to have that united to it) as many other forms are ſaid to be of theirs; nor do all the properties, or ſo much as all the ſpecifick ones, flow from that ſoul (whoſe manſion was a living animal of a determinate kind before it was united thereto) as thoſe of other natural compounds are held to flow from their forms. And even in beaſts and plants (if we will rather conſider the thing than men's opinions) if the ſoul be all the form, there will remain in the matter after the abolition of the form great ſtore of qualities, that by their ſo remaining ſhow, that they do not flow from the ſoul, as gravity is ſaid to flow from the form of the earth, and tranſparency from that of the air, and theſe ſurviving qualities are oftentimes not only many, and ſeveral of them noble and ſpecifick, as appears in the beauty, fragrancy, and cordial virtue of oranges, lemons, *&c.* but oftentimes the ſame, that were there in the body, for aught our ſenſes can perceive, whilſt it was ſaid to be informed by the ſoul. And I believe it would puzzle a Peripatetick to diſcriminate an apple or an orange, which, having been plucked off from the tree, were with a ſlender thread artificially tied on again by the ſtalk, from the other fruit as yet growing on the ſame branch. And not only the letters, that were carved on the bark of young trees, and grew with them, remain as fair and legible as ever, when the trees are cut down; but a dead body for ſome time after death (and it matters not how little a while, provided the ſoul, and conſequently the ſpecifick form be really deſtroyed or departed) does oftentimes ſo exactly retain the

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ſhape, feature, and even colour, warmth, and other qualities, which it had whilſt the ſoul (a little before) was there, that it often puzzles the beſt phyſicians (eſpecially if the ſick perſon were hyſterical or apoplectical) to diſcern with certainty, whether the patient be dead or alive. And as for that conceit of a *forma cadaveris*, whereby divers of the modern Peripateticks have attempted to decline the inconvenience of allowing, contrary to the doctrine of very many of their party, that the ſame qualities remain *in corrupto* (as they ſpeak) as were *in genito*; and that in ſpite of their general and fundamental tenet, the matter may be for ſome time (how little ſoever it imports not) without a ſubſtantial form: this cadaverous form, I ſay, that ſeems much to diſparage our ſenſes, (which witneſs divers of the remaining qualities to be the ſame they were before) ſeems to be deduced without any ground from the phænomena of nature, being introduced, (as * *Suarez* himſelf, though a friend to this expedient, ingeniouſly confeſſes) but becauſe it is conſonant to the Peripatetick doctrine, that it ſhould be ſo: (though that itſelf be not ſo evident, but that *Scotus*, and I know not how many of the Ariſtotelians themſelves, reject this form, if they do not alſo deride it.)

NOR need we be very ſollicitous, how the parts of a dead body can be kept together, if neither the ſoul, nor ſome new ſubſtantial form that ſucceeds it, perform that office; ſince competent agents, whatever they were, having contexed a portion of matter into ſuch a human body as the ſoul left upon its departure, the fabrick of the body and connection of the parts will ſuffice to make it retain for a little while (and that is enough for our purpoſe, ſince dead bodies are not wont to remain long unaltered) their priſtine ſhape, and divers other manifeſt qualities, which may continue, till the action of outward agents upon the leſs ſolid parts of the body, or the internal and inordinate commotions of the juices, and the ſofter, though not fluid parts, that are contained in it, do by their degeneration vitiate the texture, and conſequently the manifeſt qualities of it. And if theſe inordinate agitations of the blood, humours, *&c.* be hindered, though by an external cauſe, the body, notwithſtanding the loſs of the ſoul, will continue unputrified, not only for ſome hours, but for many months together; as a learned eye-witneſs, whom I inquired of, aſſured me he, as well as many others have obſerved in very cold countries as *Ruſſia*, *Sweden*, *&c.* where they often keep thoſe bodies that die in the winter unburied, and yet ſweet, till the ſpring, when the ſun's heat makes them begin to putrify. And it is plain, in ſome aromatick gums and fruits, that bodies, that were once plants, may, after they have loſt the vegetative ſoul, not only continue many years uncorrupted, but by embalming other bodies keep them ſo too.

BUT as I was ſaying, the proſecution of this inquiry *(whether in living creatures the ſoul be always the true form, to all the intents and purpoſes, that the vulgar philoſophers would have it)* belongs not to this place, elſe I might alſo queſtion the congruity of what is taught as well by *Sennertus*, as the ſchools, that upon the ſupervening of the ultimate or ſpecifick form, the forms, that thereupon become ſubordinate, do but make a part of the matter informed by the new form. I grant indeed, that they may qualify and diſpoſe the ſeveral portions of matter they belong to in ſuch a way, as that they make the body, they conſiſt of, a fitter ſubject or receptacle for the ultimate form, that is to be introduced: and there may be a neceſſity of ſuch previous diſpoſitions in the ſubject, becauſe the compounded body is of ſuch a nature, as that no other bodies, but ſuch as are thus and thus qualified, are fit to make it up. But it ſeems not to me ſo eaſy to conceive, how a ſubſtance diſtinct from matter (for ſuch both he and they make their ſubſtantial forms to be) can properly be ſaid to have its capacity confounded with that of the matter. And notwithſtanding the lately mentioned diſtinction betwixt ſpecifick and preparatory forms, thoſe (laſt named) ſeem to me as true ones, whilſt they are either ſole or predominant, as the ſpecifick themſelves. For bodies are what they are by the matter and modification, that do for the preſent conſtitute them, whatever they may prove to be in the future; and it is extra-eſſential to the form, that is ſaid to be previous, that it is to be ſucceeded by another, which is ſaid to be more noble. A ſpring of ſteel is a true and perfect ſpring, before it be madea part of the watch, and by becoming ſo, it is not really bettered in its nature, though it be made indeed more uſeful to man: and when copper is turned into vitriol, copper was a true and complete metal before, and it is accidental to the copper, that corroſive ſpirits coagulate themſelves with it into a ſalt-like ſubſtance. And antimony is true and perfect antimony before it be turned into glaſs, whether afterwards it happen to be or be not changed, by the bare operation of the fire, from a black and opacous mineral to a fine red and tranſparent glaſs.

AND though I know, *Ariſtotle* attributes to forms τιμιότης καὶ ἀτιμία; yet it is not always ſo eaſy duly to apply thoſe civil appellations to phyſical things, and to determine, whether a ſucceeding form be more or leſs noble than the precedent. As when, for inſtance, pearls are reduced by ſalts into a chymical magiſtery, and vitriol is made of iron or copper; where, for divers œconomical and military uſes, the metals themſelves are fitter than the magiſteries, (as in gold-ſmiths ſhops and on ladies necks, the intire pearls are much more prized than the prepared ones) and for other purpoſes, eſpecially in phyſick, which regards the health of man, the magiſteries are better than the crude metals. And theſe inſtances put me in mind of taking notice, that as the ſupervening of a form does not always deſtroy the old, as in vitriol (ſuch as I formerly mentioned) the copper retains its metalline nature under the diſguiſe of a ſalt; ſo upon the abolition of the ultimate form, the previous form may in divers caſes be reduced to the exerciſe of its former

 functions;

* Diſput. 15. Sect. 8. Sect. 16.

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functions; as out of ſuch vitriol as I am ſpeaking of, it is eaſy, without the addition of any metalline ſubſtance, to recover true and malleable copper. But I have dwelt too long upon this fifth conſideration, which will invite me to make ſhorter work with thoſe, that follow.

FIFTHLY, But before I proceed to them, it will not be amiſs to intimate, that one may, if one pleaſes, make ſome diſtinction between ſubordinate forms, there being one ſort of them that may deſerve a peculiar name. For in men, horſes, ſheep, and other perfect animals, there are divers parts, eſpecially thoſe, that phyſicians call ſimilar (in oppoſition to organical ones) ſuch as bones, ligaments, membranes, which ſeem evidently to challenge peculiar and diſtinct forms: for the diverſity of their nature, being very manifeſt and ſtable, perſevering oftentimes a great while (as appears in bones) after the death of the animal, thoſe that allow, that a natural body is what it is upon the account of its form, cannot well deny theſe ſo diſtinct bodies diſtinct forms; which becauſe the bodies they conſtitute are the parts of a human body, ſome modern ſchoolmen have (not very inconveniently) called partial forms. But this diſtinction being not of ſo great weight, that we need inſiſt upon it, the notice already taken of it may at preſent ſuffice.

SIXTHLY, I conſider, that among the conſtituent parts of an animal or plant, there may lurk ſome ſeminal principles or rudiments, that is, ſmall parcels of matter of ſuch a texture, that though whilſt they remain aſſociated with the other parts of the compounded body, they are not by ſenſe (eſpecially when that is imployed with no greater attention than is uſual) diſtinguiſhable from the reſt of the compounded body, comes to have its predominant form aboliſhed, theſe ſeminal principles or rudiments being ſet at liberty, and befriended by external heat, and the ſoftneſs which uſually attends corrupting bodies, and perhaps by a lucky concourſe of other circumſtances may fall to act according to their own nature, and generate inſects, moſs, *&c.* as I have more amply declared in other papers*.

SEVENTHLY, I conſider, that beſides that when the ſpecifick form of a body is deſtroyed, the change is not oftentimes ſo great as vulgar philoſophers imagine; the corruption of the animal or other body ought not to be looked upon, as if it happened in ſome of thoſe imaginary and empty ſpaces, that are conceived to be beyond the univerſe, but in this world of ours, where the body, which is deprived of its ſpecifick form, is ſubject to be acted upon by the ſun, the air, and I know not how many powerful agents, by whoſe various concourſe with, and operations upon the body, either the pre-exiſtent, though lately eclipſed forms, may be aſſiſted to ſet up for themſelves, or new forms may reſult from new leagues and contextures of the particles, that compoſed the body, that loſt its principal, or, if I may ſo call it, ſovereign form, (as we have largely diſcourſed in the lately mentioned papers. †)

THESE obſervations being laid down, to avoid the neceſſity of too much interrupting our future diſcourſe, by being obliged to interpoſe ſome of the premiſed explications and other paſſages, as obſcure and difficult, as we readily confeſs the ſubject we are treating of to be, we ſhall now adventure to try, whether about *Sennertus*'s doctrine we can propoſe any conjectures, that being as agreeable to the phænomena, as his are congruous to the corpuſcularian hypotheſis, according to which we have hitherto diſcourſed of forms.

AND (to begin with a conceſſion) I allow the learned *Sennertus* and his followers to be in the right, who, without fearing the invidious title of innovators, aſſerted, that in an animal or a plant there was ſomething elſe beſides the bare *materia prima*, and the vegetative or ſenſitive ſoul, with its eſſential faculties. And the inſtances they bring to ſhew, that in ſome parts of ſuch bodies there may lurk peculiar forms, which, when the life of the plant or animal determines, come to diſcloſe themſelves, are probable enough; and the inſtances taken by *Sennertus* from the ſpecifick virtue, that ſurvives in gathered plants, and particularly the above conſidered purgative faculty of rhubarb, are ingeniouſly alledged for their purpoſe. And it is probable too, what *Sennertus*, according to their grounds, teaches, that this purging property in rhubarb, ſenna, *&c.* as it does not flow from the vital ſoul of the plant, which is already deſtroyed, ſo it does not proceed barely from the form of a mixed body as ſuch; it being no way likely, that ſo great a variety of ſpecifick properties, as roots plucked out of the ground, and fruits torn from the tree, are endowed with, ſhould proceed meerly from that general form, that belongs in common to compounded bodies as ſuch. To which argument I forbear to add that other, wherewith it is ſeconded by *Sennertus*, though he and others of ſeveral parties are wont to lay much weight upon it; namely, that theſe properties flow from the ſpecifick form, which even in inanimate bodies is of a ſublime nature, and muſt be the author of ſuch peculiar virtues, which, according to him, being far above the reach of elementary qualities, cannot be produced by any mixture whatever of the elements: this argument, I ſay, I decline to urge in this place, becauſe I elſewhere purpoſely examine it, and having declared in what ſenſe only it ſeems to be ſafely grantable, I reject the chief ſuppoſition, on which it leans.

TO proceed then to the next part of our diſcourſe: though (as I was ſaying) there be ſome things about the doctrine of ſubordinate forms, wherein I diſſent not from theſe learned men, yet there are others, wherein I muſt confeſs my ſelf unſatisfied; for neither do I acquieſce in ſome of the notions, whereon they ground the things, wherein we agree, nor do I agree with them in ſome of the main things they aſſert: and eſpecially having in the paſt diſcourſe

* Eſſays about ſpontaneous generation.

† Eſpecially in the latter part or eſſay.

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diſcourſe rejected ſubſtantial forms, it is not to be expected, that we ſhould either employ them in our explications, or admit thoſe explications, that neceſſarily ſuppoſe them.

THEY teach us indeed, that the ſpecifick form of a body does command all the ſubordinate forms, and uſe them but as inſtruments to its own purpoſes, thoſe forms belonging then to the matter, which the ſpecifick informs and rules. But for my part, that do not acknowledge in many bodies, that are or may be ſaid to have ſubordinate forms, any thing ſubſtantial diſtinct from matter, I confeſs I do not readily conceive, which way this dominion attributed to the ſpecifick form is exerciſed, nor do I ſee any neceſſity of admitting any ſuch power in that form, nor that the portions of matter, that are endowed with thoſe forms, that are ſaid to be ſubordinate, can, being under the degrees of ſouls, and conſequently unfurniſhed with knowledge and will, pay this preſumed ſuperintendant form any obedience; I mean any other obedience, than ſome ſuch kind of one, as the parts of a clock or engine may be ſaid to yield to one another. I ſhould therefore rather conceive the matter thus; when divers bodies of differing natures or ſchematiſms come to be aſſociated, ſo as to compoſe a body of one denomination, though each of them be ſuppoſed to act according to its own peculiar nature, yet by reaſon of the coaptation of thoſe parts, and the contrivement of the compounded body, it will many times happen, that the action or effect produced will be of a fixed nature, and differing from that, which ſeveral of the parts, conſidered as diſtinct bodies or agents, tended to, or would have performed. As when in a balance, by putting in a weight into one of the ſcales, the oppoſite ſcale, though as a heavy body it will naturally tend downwards, yet by virtue of the fabrick of the inſtrument is made to mount upwards. And when an archer kills a deer with his arrow, the bow being a ſpringy body, naturally endeavours to unbend it ſelf; and the ſpring being faſtened to the bow, muſt neceſſarily follow the motion of it, and the ſhaft, though a heavy body, and, as ſuch, tending directly downwards, is by the forcible impulſe it receives from the ſpring, thrown with ſuch violence (not directly downwards, but in a parabolical or ſome ſuch crooked line) as far more ſtrongly to hit the mark, than it would (if left to it ſelf) have ſtruck the ground. So that thoſe actions; which *Sennertus* and others attribute to the conſpiring of ſubordinate forms to aſſiſt the ſpecifick and preſiding form, we take to be but the reſultant actions of ſeveral bodies, which being aſſociated together, are thereby reduced in many caſes to act jointly, and mutually modify each other's actions; and that, which he aſcribes to the dominion of the ſpecifick form, I attribute to the ſtructure, and eſpecially to the connexion of the parts of the compounded body: as in a clock, though all the parts it conſiſts of, do contribute to the performance of thoſe things, that belong to a clock, as regularly as if they intended ſo to do, and did not only concur, but knowingly conſpire in what they do, yet in all this there is no ſubſtantial form to ſuperintend their motion; but the lead (or other weight) tends downwards as it is wont to do; and the hand, wheels, and other parts do only perform ſuch motions, as they are forcibly put into by thoſe bodies, which by the deſcending weight, (that does not in the leaſt intend what it effects) are themſelves ſet a moving. And notwithſtanding the prodigious operations, that men admire in gun-powder, yet not only, as we formerly intimated, this ſtrange power is but the effect of the mechanical texture, and of the way, wherein the ingredients are mingled, and as it were contexed; but this artificial mixture is far more ſlight than thoſe made by nature are wont to be. For as the efficacy of the mechanical texture in gun-powder may appear by this, that neither of the ingredients (whether the ſulphur, the nitre, or the coal,) is apart able to produce effects any thing near like thoſe of gun-powder; ſo to convince others, how ſlightly the ingredients are mingled, I thought the beſt way was to ſhew, how eaſily they may be ſeparated again; to which effect I beat good gun-powder ſmall, and having boiled it a pretty while in a conſiderable proportion of water, by exhaling a ſufficient quantity of the well-filtrated and limpid decoction, I obtained ſtore of cryſtals, whoſe figure, taſte, and way of flaſhing upon a quick coal proclaimed them to be good ſalt-petre; the black ſtuff left in the filtre remaining, if the ſolution had been well made, inſipid enough, and when dried it will not blow up like the gun-powder, but (in great part) burn along with a blue flame like common brimſtone. And for farther proof we may, by boiling this black ſtuff in a pretty ſtrong lixivium, diſſolve the ſulphur, as will appear both by the ſmell, that the lixivium will acquire, and by this, that if you filter it, though the liquor will paſs clear enough, and leave the black and coal-like part in the filtre; yet by dropping into it ſome quantity of an acid liquor (I uſed ſpirit of ſalt) the ſulphureous ſmell will be increaſed, and the liquor will be made white by the precipitation of the ſulphureous corpuſcles; whereas if I put ſpirit of ſalt into that clear ſolution, which (I was ſaying) afforded me the cryſtals of nitre, the liquor, not troubled by any ſuch precipitation, would continue limpid as before; which argued, that the ſalt-petre had not intimately incorporated any ſenſible quantity of the ſulphur with it ſelf, but had been only ſlightly aſſociated with it.

AND to illuſtrate what I ſaid of reſultant actions by an inſtance purely phyſical, I ſhall ſubjoin what I ſomewhere mention, with another aim, that by taking a couple of powders fit for my purpoſe, one blue and the other yellow, and mingling them in a certain proportion, the mixture exhibited a green colour, which did not flow from any new predominant form, which made the blue and yellow corpuſcles ſubſervient to its purpoſes, (for an excellent microſcope ſhewed me the blue and the yellow particles ſuch as they were before) but only hence, that from the mixture of thoſe bodies, the

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the diſtinct actions of the blue and the yellow corpuſcles did upon the eye make a compounded impreſſion, like that made by bodies, to whom their ſpecifick forms are ſuppoſed to impart, among other qualities, greenneſs. And when vitriol or ſublimate are made by art, there needs nothing beſides the manner, wherein the ſaline and metalline particles are contexed, either to contain the parts together, and keep them united into one body, or (notwithſtanding their not only diſtinct, but very differing forms) to enable the mixture they compoſe, to effect divers things, which neither of them ſingle would have performed: nay and ſome of them ſuch things (as to vomit, purge, *&c.*) as merit to be reckoned among ſuch ſpecifick properties, as many of thoſe are, which when preſerved in vegetables, are thought to argue the conſpiring of ſeveral forms under the direction of a ſuperintendent one.

AND as in a watch the ſpring is really a ſpring, and acts as a ſpring, whilſt it is a part of the watch, though by reaſon of its connexion with the other parts it is reduced to concur with thoſe other parts towards exhibiting the phænomena proper to the whole engine; and though the watch were taken all in pieces, the ſpring would be a ſpring ſtill: ſo in many compounded bodies, beſides the ſpecifick form, which the body has as ſuch, and which may be called its total or general form, particular bodies (by whoſe aſſociation and conjunction it is made up) may enjoy their own diſtinct forms, which may therefore be called partial ones; and theſe bodies, though whilſt the whole ſubſiſts they are part of it, and by their connexion with the reſt concur to the operations of the body as ſuch, which joint operations are wont to be thoſe, that are attributed to the ſpecifick form; yet they do not always ſo depend upon it, but that when it is aboliſhed, they may retain their own nature; as a bone will be a bone ſtill, whole ages after the animal it belonged to is dead: whence we need not wonder, that divers forms ſhould ſurvive in bodies deprived of their ſpecifick form. For indeed thoſe, that are called ſubordinate, may be as true and real forms (nay, and ſubſtantial forms, if in any living creature, beſides man, there were any ſuch) as that, which bears the title of ſpecifick; and even whilſt this is in being, there are many things, which compounded bodies perform by virtue of their particular forms, rather than upon the account of the ſpecifick: as (not to repeat the newly mentioned inſtance of a ſpring) in vitriol the friableneſs, tranſparency, and aptneſs to mingle with water, need not be attributed to the compoſitum as ſuch, but may, for aught we know, be due to the ſaline corpuſcles, which not only retain their own nature, (as may be argued from ſome vitriols, that I have made, ſince I have been able to ſeparate and recover them again out of the mixture) but to reduce the metal, they have corroded, into a ſalt-like body with themſelves. And in gunpowder it is manifeſt, that the blackneſs proceeds not from the compoſitum as ſuch, but from the coals, as the nitrous taſte does from the ſalt-petre. And the fragrancy of a roſe, whilſt it grows upon the buſh, need not be conceived to proceed from the ſoul or life of the plant, ſince, when it is gathered, it retains the ſame grateful ſmell.

AND this laſt inſtance leads me to a farther conſideration, wherewith I ſhall conclude this diſcourſe. We may call to mind what was obſerved a little after the beginning of it, of the arbitrary, or at leaſt not ſufficiently ſettled uſe of the word *form*; and that it not ſeldom happens, that thoſe things, upon whoſe account we attribute this or that form to a natural body, are but very few of thoſe many attributes that belong to it. Now the form of a body being really no more than a convention of accidents, whereby the matter is ſtamped and denominated, it is very conſonant to reaſon, that oftentimes hoſtile agents or cauſes may deprive the matter of thoſe accidents, which conſtituted the ſpecifick form, and yet leave the reſt, which, according to the law of nature, ought to continue there, till ſome competent agent put the body out of that ſtate, wherein, upon the form's deceaſe, it was left.

AND to clear up this matter, we may conſider, that the ſame body may have a twofold modification, and be thereby fitted for two, if not more, ſtates and kinds of operations, not neceſſarily dependent upon one another. For as the ſpring of a watch by virtue of its texture is an elaſtical body, and upon the account of another is iron, and therefore though being caſt red-hot into cold water it will become ſtiff and brittle, and conſequently ceaſe to be a ſpring, yet it will continue iron, that is, a hard metalline body eaſily ſubject to ruſt, capable of ſtriking fire with a flint, and of being attracted (as men commonly ſpeak) by a loadſtone, and of attracting a magnetical needle; ſo in a roſe, for inſtance, we may diſtinguiſh or conſider a twofold modification of the matter, one, whereby it is fitted to receive from the buſh it grows on a certain peculiar and ſpirituous ſap, by whoſe intervention and concurrence it has nouriſhment and growth, and conſequently exerciſes vital functions as a part of a living plant; and another, which does not ſo much require the acceſſion of fluid and moveable parts, but conſiſts rather in the texture of the more ſtable parts: and this texture being commonly more permanent and durable than the other part of the modification, (conſiſting much in the peculiar motion of a fluid ſubſtance) wherein the life participated by the roſe conſiſted, may laſt, when the flower is deprived of its ſoul and ſpecifick form by its avulſion from the buſh, and retain thoſe qualities, as well occult as manifeſt, that naturally reſult from a parcel of matter ſo contrived.

I MAY ſomewhat illuſtrate my meaning on this occaſion, by making a compariſon betwixt a living creature and a mill. For as a mill is capable of performing divers things only when the water, that paſſes through certain of its parts, puts them, and by their intervention, others into motion; ſo there are divers things, that are not performable by a plant, unleſs when it is irrigated by a vital liquor. And as a mill may nevertheleſs retain the nature of a

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ſtructure uſeful for other purpoſes, though the drought of ſummer have perchance made it looſe, or the froſt have congealed into ice the water, that uſed to drive it; ſo although the ſoul of a plant be deſtroyed, or ceaſe to act, the body may, upon the account of the more permanent ſtructure of its ſtabler parts, retain a fitneſs for divers of the ſame purpoſes it ſerved for before. And if it were here pertinent, the compariſon might be carried on a little farther, by adding, that as when a mill does upon either of the lately mentioned accounts ceaſe to perform the peculiar operation of a mill, as the wood, iron, and other materials of that mill are not deſtroyed; ſo neither does the water vaniſh into nothing, but either loſes its motion, and by being congealed exchanges the name of water for that of ice, or elſe is diſſipated and ſcattered into exhalations, which contain all the ſubſtance, that ever the water had, that, which is loſt, being but the uſual manner of coëxiſtence of the water and the mill it was wont to drive: ſo when a plant is pulled out of the earth, or a roſe from the buſh, as the diſmembred part of the plant may retain the texture of its more ſtable parts; ſo the ſap or juice, that were wont to enliven the body, does, though inviſibly, remain either in the form of ſteams exhaled into the air, or perhaps in parts condenſed and intercepted upon the loſs of its wonted agitation in the imperceptible cavities of the fibres, and other parts of the plant, ſo that nothing, that is ſubſtantial, periſhes, but only the particular modification, that reſulted from the peculiar kind of union of the more permanent parts with thoſe congruouſly ſhaped and fitly agitated fluid ones, that permeated them. As to ſome purpoſes, the example of a wind-mill, being ſet on work merely by the impulſe of the air, may be more appoſite than that of the water-mill; but neither of them affords any more than an imperfect compariſon in this regard, among others, that whereas the mill itſelf by loſing, even for a very long time, the motion it was wont to be in, is not thereby conſiderably impaired, becauſe of the ſolidity of the materials it is made up of; in vegetables, when that fluid ſubſtance, whereof the ſoul chiefly conſiſts, quite ceaſes to be influent, one of its chief functions being to repair continually, by aſſimilated or tranſmuted aliments, the waſte, that was continually made of looſer parts in the body it belonged to, the ſame agents or cauſes, that deſtroyed the life of the plant, are wont likewiſe to produce or occaſion ſuch a diſcompoſure in the texture of the remaining part, (eſpecially thoſe, that are more tender or more ſlightly connected) that they quickly become unfit to be animated again, though a fluid ſubſtance, like that, which was wont to irrigate it, whilſt the vegetative life laſted, ſhould be again communicated to it; but yet even in this regard the difference betwixt a mill and a plant is not always ſo vaſt, as one would imagine. For in claſſick authors we have relations of a ſtaff or a pike made of a durable wood, that many years after the tree had been cut down, being caſually ſtruck into the ground, took root there. And as for the roſe of *Jericho*, as they call it, a late modern writer, followed, as I remember, by another naturaliſt of good account, affirms, that divers years after it is gathered, and ſeems to be quite ſhriveled up and withered, it may by the help of water be ſo far recovered, as to be plumped up again, and diſplay its leaves almoſt as if it had not been long ſince gathered. And I my ſelf have, not without ſome wonder, obſerved, how very long a plant of aloes torn from the ground, and hung in the air near the cieling of my chamber, would not only continue ſucculent, but (perhaps after ſome years) be capable of being made to perform acts, that are wont to be aſcribed to vitality and growth, upon the dexterous adminiſtration of a convenient liquor: and even ſome animals themſelves are not ſo very unlike to theſe plants, and conſequently to engines, as one would think. For that, which children are ſaid to do for ſport about reviving drowned flies, challenges a more ſerious conſideration than were fit for me to inſiſt on now, and deſerves to be both heedfully experimented, and ſeriouſly reflected on by a naturaliſt. I choſe to try it chiefly upon waſps and bees, rather than upon flies, becauſe their bigneſs renders the phænomena more conſpicuous; and having drowned them ſo, that, if let alone, they would not in probability have ever recovered, I found, that the heat of the ſun would recover them, as well, as it has been obſerved, that warm aſhes would recover flies; (ſo that theſe trials argue celeſtial heat to be as little more as leſs vital than elementary:) and the degrees and manner of their recovering again the operations of life ſuggeſted obſervations, not unworthy to be taken notice of elſewhere, though not fit to be delivered here; where I ſhall not ſo much as mention what with warm applications we have done, to revive the expired motion of the parts even of perfect and ſanguineous animals, when they ſeemed to have been killed; becauſe I fear, that the excurſion I have unawares made already will be looked upon as too much a digreſſion.

WHEREFORE, to take up my diſcourſe where a while ſince I left it; I ſhall proceed now to obſerve, that even in a body, that has loſt its ſpecifick form, the noble qualities, that remain, do not always flow from the form of the entire body as ſuch, but from the peculiar form of ſome particular parts of that body, which being ſeparated from it, though perhaps the more ſtable parts, that remain, will keep the viſible ſtructure from being manifeſtly altered, yet this remaining body will be quite deprived of the noble properties we were mentioning; as may be gathered, as well from what has been above mentioned out of *Sennertus* about drawing an extract from rhubarb, in which its whole purgative virtue reſides, as in ſome preparations of cinnamon, and divers other ſubſtances endowed with fine parts, which upon the loſs of thoſe parts remain but the carcaſſes of what they were. And even in the groſs bark of oak, tanners find, that when the water has extracted the diſſoluble parts, or time has waſted ſome ſubtile parts, and changed the texture of the reſt, though the bark re-

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tains its outward form, they cannot make uſe of it as they might have done before. And (as I formerly intimated*) beſides this pre-exiſtent and ſurviving modification, it is in divers caſes very poſſible, that new qualities and properties (whoſe principle may be called a form) may be diſcloſed upon the aboliſhing of the ſpecifick form, though they were not actually in any part of the matter, but are produced in it by a concurrence of the texture and diſpoſitions left there by the late form, and the operation of external agents. As when out of the fleſh of a dead animal there is generated muſk; for not only thoſe ſeminal rudiments, that actually were latitant in the corrupted body, gain opportunity to ſet up for themſelves, and become perfect inſects, or other creatures of their own kind, but the external agents, to whoſe action, according to the common courſe of providence, deceaſing plants or animals happen to be expoſed, do oftentimes (not without the foreknowledge of the moſt wiſe author of nature) ſo agitate the ſmall parts of the widowed matter, and perhaps by aſſociating themſelves with them, do ſo alter their texture, and thereby introduce a new modification, that by the conjunction of the former diſpoſitions, that were regularly left in the matter with theſe new agents, promoted by a concourſe of favourable circumſtances, there may be produced new and noble forms; (however not vital ones.) As when a limeſtone, being calcined and left in the open air, will in tract of time, as I have particularly obſerved, by the aſſiſtance of congruous particles it meets with there, and befriended by the more catholick cauſes of phyſical mutations, afford true and inflammable ſaltpetre; and I have ſeen certain marcaſites, that, being burnt and expoſed to the air in convenient places, would have ſuch a change produced in their parts, as, after a due time, to afford an efflioreſcence, which both by the colour, taſte, and operation appeared to be vitriol.

BUT of ſuch matters no more at preſent. I will rather take notice, in proſecution of what I was not long ſince obſerving about the twofold modification of living creatures, that I fear we ſometimes attribute to the ſpecifick form or ſoul, things, that may be well enough perform'd without it, by the more ſtable modification of the body, befriended by an eaſy concourſe of natural agents. Thus, though the excluſion of excrements be unanimouſly aſcribed to the ſoul, which for that purpoſe is ſaid to be endowed with a peculiar faculty, that they call expulſive; yet it has been obſerved and affirmed by many, that divers times the excrements have been diſcharged out of the bodies of men a good while after they were unqueſtionably dead; ſo much (it ſeems) of the former ſtructure of the parts remaining, as ſufficed to cooperate with the excrements themſelves, changed by the death of the animal, to that excluſion. And thus (to add an inſtance of another kind) though the maturation of fruit be a great, and, as the ſchools ſpeak, a perfective alteration, which is ſuppoſed to be wrought by the vegetative ſoul of the plant; yet it has been vulgarly obſerved, that apples and grapes gathered before they be ripe, and laid on heaps together, will ripen well enough afterwards; (and the example were more eminent in medlars, if what ſome call their ripeneſs, others did not call their rottenneſs.) And very remarkable is that account, which the inquiſitive *Oviedo* gives the emperor *Charles* the fifth of the Anana's, if I miſtake not the name; which having mentioned as one of the conſiderableſt fruits he met with in the *Weſt-Indies*, he takes notice, that though, notwithſtanding their largeneſs, they grow in cluſters, yet they muſt be gathered whilſt all but one are green. For as ſoon as the firſt begins to be yellow, the whole cluſter muſt be taken off, leaving the reſt to ripen, and attain to the ſame colour in the chamber, which they will very well do. The learned †*Joſephus Acoſta* ſpeaks thus of the fruit of the plane-tree, to the ſame. "This fruit (ſays "he) inclines more to cold than heat."—— They are accuſtomed to gather the boughs or cluſters (as I have ſaid) being green, and put them into veſſels, wherein they ripen being well covered, eſpecially when there is a certain herb mingled with it, which ſerves for this effect. But the diligent *Piſo*, ſpeaking of thoſe Braſilian plants, which he calls Pacoeira and Bananiera, punctually relates that, which comes up yet more fully to our preſent purpoſe. For not only ſpeaking of the fruit, he ſays‖, *continentur plerumque in uno ramo quatuordecem aut ſedecem numero, ut ita una planta proferat ſeptuaginta aut octuaginta, qui ſubinde virides avulſi, nunc in ædibus, nunc in navibus ſuſpenduntur, donec juſtam maturitatem & flavedinem conſequantur:* but adds this memorable paſſage concerning the lopped boughs themſelves; *Ramus autem ille fructibus onuſtus, interea dum illi matureſcunt, augetur, floreſque ſemper protrudit ex corpore illo foliaceo, &c.* On this occaſion I might here add, that even in our cold climate, onions and ſome other bulbous plants will in the ſpring-time ſhoot out of their own accord. And I have taken pleaſure to keep potatoes in the air, to obſerve, how at that ſeaſon, when they uſually begin to ſprout in the ground, they would put forth leaves at ſo many of the little holes or dimples, as to give themſelves a verdant livery: but that not being willing now to examine, whether or how far an animated ſeed may have an intereſt in theſe laſt mentioned productions, I will rather take notice, that even in animals ſome things, that are confidently preſumed to be the proper effects of the animal's ſoul, may be really performed by the texture of the body, and the ordinary and regular concourſe of external cauſes. For (not here to repeat what I lately noted of the excluſion of excrements in dead bodies) though the nails of a man are nouriſhed, and do grow as well as other parts; and though the hair in moſt animals be ſometimes, even in determinate parts of the body, peculiar to the ſpecies of animals, to which it belongs; and though in man hairs do not only grow, but in the diſeaſe called the *plica Polonica*,

* Eſpecially in the 5th and 6th conſiderations. † *Acoſta, lib. 4. p. 269.* ‖ *Piſo, Natur. Hiſt. cap. 21. pag. 155.*

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tonica, it appears to participate of blood, (ſince the hairs being cut, weep out that liquor) yet nails themſelves are obſerved to grow in dead men. And that they do not ſo only (as is ſuppoſed) for a little time, whilſt the impreſſions left by the ſoul upon the carcaſs are yet vivid and recent, but for a much longer while than has been imagined, I have been with pleaſure informed by a memorable obſervation I met with in the experienced **Paræus*, who ſpeaking of a body, that he by imbalming preſerved for more than twenty five years, he affirms it ſtill remained whole and ſound, and that, as to the nails, he found, that *having often pared them, he ſtill obſerved them to grow again to their former bigneſs.*

I KNOW the patrons of *Sennertus*'s opinion look upon it as a clear and cogent argument, to prove the ſoul's performing almoſt all things done in the body, that in the corpſe of a man or other animal newly dead, though the organization remain the ſame, yet all the animal and vital functions perfectly ceaſe. But beſides that I have already taken notice, that ſome things wont to be attributed to the ſenſitive ſoul may be obſerved in a body avowedly dead, I confeſs, that this argument ſeems to me, though very ſpecious, yet grounded upon what is but precarious. For though it may be true, that the viſible fabrick may continue for a while without any manifeſt alteration, yet who can aſſure us, that the internal organization is not conſiderably changed and vitiated? For the body of an animal is an engine, that conſiſts not only of ſolid and ſtable parts, as bones, muſcles, ſkin, *&c.* but of divers ſoft ones, as the brain, nerves, *&c.* and of ſome that are fluid, as the blood, and other liquors; and, which is in our caſe exeeedingly conſiderable, requires a convenient coaptation, or compoſition of all theſe: whence it follows, that the external frame of the body remaining unaltered, yet upon death there may be great and ſad alterations in the texture of the blood and humours, and in the contexture or ſtructure of other internal parts. And theſe changes may quite ſpoil the organization of the body, and make it unfit to perform the wonted functions of ſuch an engine. Thus we ſee, that in dead bodies, even whilſt they are warm, the blood oftentimes coagulates in the veſſels, whereby the circulation, that grand wheel of life, is ſtopped. And in ſudden palſies, though there be uſually no viſible change in the affected limb, yet it loſes ſenſe, or motion, or both: and not only in ſyncopes or great ſwoonings, and in apoplexies, a great part of the animal functions are for the time ſuſpended or unperformed; but even in ſo natural a ſtate as ſleep, the body appears not to move, nor do ſounds and odours affect the ſenſes, as when one is awaked, though the ſoul be preſent in the body, and the ears and noſtrils be open. And how great changes in the nature of liquors, and conſequently of the blood, may be produced without any viſible alteration, may be gueſſed at by what often happens in wine upon thunder: for that liquor, which was pleaſant, ſpirituous, inflammable before, ſpeedily degenerates into a ſour and uninflammable vinegar. Which inſtance will not, I ſuppoſe, appear inconſiderable to thoſe many modern philoſophers and phyſicians, that would have life maintained by a *biolychnium*, or vital flame continually burning in the heart, and fed by the ſpirituous parts of the circulating blood.

IT were not perhaps time miſpent to proſecute ſuch inquiries, as we have lately touched. But though I did not want leiſure, I ſhould be diſcouraged by conſidering, that even ſome of the things I have already delivered, may be queſtioned by thoſe who take not the word *life*, and ſome other terms by me imployed, in the ſame ſenſe that I do. And indeed it is very difficult, that men ſhould avoid falling either into miſtakes, or into unprofitable diſputes, if they diſcourſe largely of ſuch themes, where the names, that are of a very common and neceſſary uſe, have (yet) their ſignifications very little ſtated or agreed on. For *life*, for inſtance, is a word, whoſe meaning is not yet defined, and is applied to ſubjects, that are exceeding different. For it is aſcribed not only to all ſorts of animals and plants, but by many chymiſts and mineraliſts to ſtones and metals growing in the bowels of the earth. Nor is it attributed only to things corporeal, but to thoſe, that differ *toto genere*, as they ſpeak, from them; namely, to ſeparate ſouls, angels good and bad, and to God himſelf. Nay, what that is even among animals, wherein it conſiſts, is not yet ſufficiently agreed on; as may appear by the diſpute among the modern naturaliſts, whether prolifical, but as yet unhatched, eggs have life or no? and whether flies be really dead in winter, which ſome affirm them to be, not only becauſe thoſe inſects ſeem to be devoid of ſenſe and motion, but becauſe they place the notion of life in a conſtant circulation of the blood, or ſome analogous juice, and a diſtribution of the aliment thereby performed to repair the waſtes of the body; whilſt others, on the contrary, think them to be rather benumbed than dead, becauſe regularly recovering the manifeſt actions of life in the ſpring, (or oftentimes before, if a due application of heat be made unto them) it cannot be ſuppoſed, that they were during the winter really deſtitute of life: death being a privation, which, by phyſical means, admits not of a return to the former ſtate. Nor are the boundaries and differences betwixt the life of a plant and that of an animal ſo ſettled and defined, but that divers not impertinent queſtions may be made about them; and particularly it may be doubted, whether ſome parts, as nails, hair, horns, *&c.* that belong to the body of an animal, may not for all that (even whilſt he is alive) have the nature of a plant, to which the part where it grows, ſerves as the ſtock does to a graft for a ſoil, and is but an appropriated one. But to do more than point at ſuch matters, would add too much to the digreſſions, of which I fear the paſſed diſcourſe may be thought to be guilty already. I ſhall not therefore add any thing at preſent further about

* *Paræus, lib.* 28.

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about the ſubordinate forms of plants and animals: but in regard I ventured, about the beginning of this little tract, to aſcribe ſubordinate forms to divers bodies, that never had life, which I doubt will ſeem a paradox to many, I think it will not be amiſs to apply the chief points of our doctrine about ſubordinate forms to inanimate bodies, becauſe this courſe, as it will invite me to make ſome new, though ſhort additions, to illuſtrate and enlarge ſome points; ſo it will help to recal to your memory moſt of the heads of that doctrine, which the ſeveral excurſions whereto divers ſubjects tempted me, may have kept you from taking a diſtinct view of. And for order's ſake I ſhall caſt the main things, I would have conſidered, into diſtinct propoſitions, with ſhort comments annexed to them; having only intimated in general once for all, that you will not, I hope, wonder, that I ſhould often uſe for examples, ſuch bodies as are looked upon as factitious, if you recal to mind what I have formerly ſaid to ſhew, that the difference betwixt them and thoſe that are confeſſedly natural, is not always near ſo great as men are wont to imagine. To which I ſhall now add, that in the following diſcourſe they are often imployed, not ſo much to prove, as to illuſtrate the notions, on whoſe occaſion they are alledged; which ſure they may very properly do. And among the bodies themſelves, in whoſe production man's power or ſkill has a ſhare, I reckon, that there is a great difference between thoſe, wherein man gives an outward ſhape, ſuch as himſelf deſigns, by tools of his own making, that are always external to the produced body, and thoſe (ſuch as are moſt chymical productions, beſides others) wherein his chief work is to apply phyſical agents to patients, by which means it oftentimes comes to paſs, that (as in productions, that all allow to be natural) the inſtruments he works by are parts of the matter it ſelf he works upon, or at leaſt intrinſical to it. But of this more perchance elſewhere; I come to the propoſitions themſelves.

I. THE word *form* is of a ſufficiently indeterminate ſignification.

THIS I have already had occaſion to ſhew, and it can ſcarce be denied by them, that ſhall conſider, though it be a technical word or term of art, yet men have not intelligibly defined and agreed, on how many, or what things, they are ſufficient to intitle a portion of matter to a determinate and diſtinct form. For beſides that there are I know not how many bodies, ſuch as treacle, beer, gun-powder, coal, ink, *&c.* about which men ſeem not ſo much as to have conſidered, whether they ought to have particular forms aſcribed to them, (or to be looked upon only as factitious things) there are other bodies, that have been taken notice of, about which even the Peripateticks diſpute, whether they ought to have particular forms allowed, or no. For not only ice is by ſome made to be a diſtinct kind of natural body, whereas others will have it to be only water altered, and thereby deprived of its fluidity, not its form; but even touching the elements themſelves, the ſchoolmen fiercely diſpute, a whole party denying them to have any other forms, than the firſt qualities, by which they are wont to be diſtinguiſhed. If I affected paradoxes, I might here add, that perchance there may be bodies, which as they may be diverſly conſidered, ſeem to have a title to more than one form, and upon that ſcore may puzzle the ſchools about the aſſignation of their forms. When, for inſtance, I have (though not without ſome difficulty) reduced lead *per ſe* into a body like that, which chymiſts call *vitrum Saturni*, and which they make by the addition of flints ſand; and it is not eaſy to determine, whether this ſhall be one of thoſe kind of bodies, that are called metals, and in our inſtance is only diſguiſed, or belongs to that other kind of bodies we call glaſs; for it ſeems to have the properties of both. For, like lead, it is very ponderous, and diſſoluble in aqua fortis and ſpirit of vinegar, which diſſolve not common glaſs; it affords a very ſweet ſolution, as lead is wont to do; and, which is more, it may without addition by bare heat be quickly reduced in great part into true and malleable lead. On the other ſide, it is a body fuſible, tranſparent, and brittle, which are the three grand properties of glaſs; beſides which, I have obſerved in it ſome others, that will be more properly taken notice of elſewhere. So likewiſe when miſletoe grows (as I have ſometimes ſeen it) to a very great bigneſs on a hazle, which (you know) is but a very ſmall tree; or when an apricock or peach is inoculated, and proſpers upon the bough of a plumb-tree, the reſt of whoſe branches bear plumbs as they did before, (to which I might add ſome inſtances of trees, that I have ſeen to bear more kinds of fruit;) and when red or blue amel is made, which conſiſts of calcined tin, which they call putty, and of the ſalt and ſand (or fuſible ſtones) whereof the glaſſmen make what they call their fritta, and of ſome burnt copper, or ſome other metalline pigment, moſt, if not all, of which ſo differing ingredients may perchance be re-obtained out of the amel, which has divers properties of the reſpective bodies it conſiſts of, and yet wants others of them; if, I ſay, ſuch examples as theſe, to which I could add ſeveral others, were propoſed, it would perhaps ſomewhat perplex the ſchoolmen, to accommodate them fairly to the vulgar doctrine of forms, at whoſe framing probably ſuch inſtances were not dreamed of.

II. IT is not eaſy to decide the nobleneſs of forms.

THIS point alſo has been partly handled already, which will make it the leſs needful to inſiſt long upon it; and indeed, beſides that nobleneſs is rather a civil or political than a phyſical qualification, it is oftentimes difficult enough to determine even in this ſenſe of nobleneſs, which of the two forms is the moſt noble. Of this difficulty we have already elſewhere given ſome examples, to which we may add, beſides the lately mentioned inſtance of the glaſs of lead, that of antimony made *per ſe*; crude antimony being fitter for ſeveral pur-

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poſes both mechanical and medical, than the vitrified calx; and this again being better for divers other uſes, than that, which has not been freed from its more fugitive parts.

IT ſeems it was diſputable among the ancients, whether or no their electrum (which learned men tell us was a compoſition of gold and ſilver) was a nobler thing than either of thoſe metals. And it may be queſtioned, whether, when chymiſts have made a precipitate of gold and mercury, the produced powder be a nobler thing than the gold alone. For chymiſts think it worth while to put themſelves to much trouble and ſome charge to bring gold, by the addition of mercury, to this new ſtate; and therefore if a ſpagyrical phyſician were judge, he would think, that in ſuch a medicine the gold is improved by the change: but if a goldſmith were to be judge, he would conclude, that gold being the nobleſt of metals, an alloy muſt needs imbaſe it; and he would take the pains, by melting it with borax or ſome other additament, to free the gold from the quickſilver, and reſtore it to its priſtine form.

IT may alſo be diſputed, whether, though in living creatures the ultimate form be wont to be more noble than its previous harbinger, it may not be ſometimes otherwiſe in bodies inanimate, as well as in the productions of art. I will not urge for an example to this purpoſe, that when corn is ground in a horſe-mill, though the whole aggregate conſiſting of the horſe, the wheels, grindſtones, and other parts of the mill, be looked upon but as one engine in reference to the uſe of the whole, which is comminution of grain; yet the horſe, though contained in the mill, and looked on as a part of it, is of a much nobler nature than the engine, to whoſe effects it co-operates. This example, I ſay, and others of the like kind, (as that of a turnſpit-dog, included in a wheel, to make it go round) I ſhall not preſs, but rather give this for an inſtance, that when an artificer, who makes ſilver ſodder, adds to the ſilver a certain proportion (which I have elſewhere ſpecified) of braſs or copper, and melts them together, though he thereby obtains a mixture, of good and frequent uſe for joining together the pieces of braſs and ſilver inſtruments, and ſtopping holes and cracks in them; yet it may be much queſtioned, whether this brittle ſubſtance be not leſs noble than the ſilver alone was. And when a plant, that grows by ſome petrifying ſpring, by imbibing that water is at length turned into a ſtone, though the rarity of ſuch things makes men prize them; yet it may well be queſtioned, whether the ſupervenient form be not leſs noble than that, which the plant had before.

III. In divers bodies the form is attributed upon the account of ſome one eminent property or uſe; which, if it be preſent and continue, though many other things ſupervene or chance to be wanting, the matter is nevertheleſs looked upon as retaining its form, and is wont to be allowed its uſual denomination.

AN example of this we may be furniſhed with by our lately mentioned inſtance of *vitrum antimonii*: for the account, upon which we take a body to be a glaſs, being chiefly fuſibleneſs and tranſparency, this antimonial preparation, by virtue of thoſe qualities, paſſes without ſcruple for glaſs, and would in effect be taken for yellow or red glaſs, (according as it happens to have more or leſs of tincture) by an indifferent ſpectator, who were aſked what it is. And yet this ſubſtance is not only by its ſolubility, unfixedneſs, and diſpoſition to afford a regulus, very differing from common glaſs, but retains ſo much of an antimonial nature and properties, as to be vomitive and purgative, as well as *crocus metallorum*. It can ſcarce be unknown to chymiſts, that there is a vaſt difference between thoſe liquors, that are expreſſed out of olives, almonds, and other unctuous vegetables, and thoſe fine eſſential oils, as they call them, which are drawn by the help of water in limbecks; and even of theſe, ſome are wont to ſwim upon water, as oil of aniſeeds or nutmegs; others to ſubſide, as the oil of cloves and cinnamon, *&c.* well drawn; and all theſe eſſential oils are very differing from the oil of guaiacum or of box, and other empyreumatical oils, that are diſtilled in retorts by the violence of the fire; and theſe do as much differ from expreſſed oils as from eſſential ones: and yet all theſe ſo differing liquors are reckoned among oils, becauſe they agree in this, that they are fluid bodies, unctuous to the touch, and mingle not with water. And ſo although ſome ſorts of ſalts be very fugitive, (as the volatile ſalts of hartſhorn, urine, *&c.*) others very fixed (as that drawn from the calx of tartar, and from the aſhes of wormwood; aſh, celandine, and other plants;) and though ſome ſaline liquors, as vinegar and juice of lemons, are acid, and diſſolve pearl, coral, *&c.* which lixiviate ſalts, whoſe taſte is fiery, will precipitate what the others have diſſolved; yet all theſe are numbred among ſalts, becauſe they agree in the accounts upon which we allow bodies that denomination; namely, their being very ſapid, and readily diſſoluble in water. Examples to the ſame purpoſe with the foregoing I could give you in flame, ſmoke, glaſs, coal, and divers other ſorts of bodies. And indeed by reaſon of the unſettled notion and almoſt arbitrary uſe of the word, *form*, I have obſerved it to be ſo uncertainly applied to the conſtituting of the diſtinct claſſes or kinds of bodies, that I have doubted, whether divers of thoſe forms, by which ſuch kinds are conſtituted, be not a kind of metaphyſical conceptions, by virtue of which, bodies very differing in nature are comprized in the ſame denomination, becauſe they agree in a fitneſs for ſome uſe, or in ſome other thing, that is common to them all: as whether a bullet be ſilver, or braſs, or lead, or cork, if it ſwing at the end of a ſtring, it is enough to make it a pendulum; and whether a burned body be chalk, or rag-ſtone (which is very hard and coarſe) or alabaſter, which is a ſoft and fine ſtone, or an oyſter-ſhell, or a cockle-ſhell, or a piece of coral; yet if it have been calcined to whiteneſs, it is lime, rather than ſuch true phyſical forms, as are ſaid to make the bodies, that have forms of the ſame denomination, to be of the ſame ſpecifick nature. However, theſe forms ſeem to be very

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generical things, and more ſuch than is commonly heeded. And I have alſo ſometimes queſtioned, whether ſome of thoſe things, upon whoſe ſcore men conſtitute bodies in this or that ſpecies or claſſis, be ſo properly the true and intrinſick forms of thoſe bodies, as certain ſtates of matter, wherein bodies very differing in nature may agree. As water, wine, and I know not how many other differing liquors, may each of them apart be made, by congelation, to paſs into that ſort of body we call ice. And not only the tallow and greaſe of animals, and the expreſſed oils and ſpirits of fermented vegetables, (ſome whereof differ exceedingly among themſelves) but alſo (as I have tried) divers mineral and even metalline concretes may be made, (ſome of them without deſtruction of their nature) to paſs into that claſſis of body we call flame.

IV. BY reaſon of the conjunction or connexion of the parts, that make up a *totum*, (or at leaſt an aggregate of bodies, that for their connexion are looked upon as ſuch) it will often happen, that ſeveral things will be performed by the joint or concurrent action of theſe united (or coherent) parts.

THESE kinds of operations are of kin to thoſe mentioned by the ſchoolmen, when they tell us, that ſome things are done by divers agents *actione communi:* as when a man diſputes *vivâ voce* ſyllogiſtically, the rational ſoul, which dictates the words, and the vocal organs, that pronounce them, are *actione communi* the efficients of the pronounced ſyllogiſm. But to give an inſtance nearer to our purpoſe; when a bullet is let fall upon a level pavement, though it touches the body it falls on but in a very ſmall part of its ſuperficies, (geometricians having demonſtrated, that a perfect ſphere can touch a perfect plane but in one point;) yet the plane receives the action of the gravity of the whole body; thoſe parts, that do not immediately come to touch it, ſtriking it nevertheleſs by the intervention of thoſe that do. And ſo likewiſe in a boat, the limbs and clothes of a man, that ſtands upon the deck, and all the parts of a watch, if he carry one in his pocket, gravitate concurrently on the veſſel, though only the ſoles of his feet or ſhoes do immediately preſs upon it, and the wheels and other parts of the watch may be moving at the ſame time very differing ways. Now in organical bodies, and divers others both natural and factitious, thoſe things, that are performed by the parts as in a ſtate of conjunction, and as it were conſpiring, or (if you will have it ſo expreſſed) *actione communi* (which action may ſometimes be ſucceſſive) are oftentimes aſcribed to the form: as in a watch, moſt of the chief of the phænomena do ſo depend upon the concurrent action of the ſeveral parts, that few of them can be out of order, but that they will hinder thoſe phænomena to be at all, or at leaſt to be well and regularly produced.

V. WE may yet in a ſound ſenſe admit, that in ſome bodies there may be ſubordinate forms.

WHAT I mean by *a ſound ſenſe* in this propoſition may be clearly collected from ſeveral paſſages of the paſt and remaining parts of this diſcourſe, where we carefully exclude thoſe ſenſes, in which we do not allow the received doctrine of ſubordinate forms. Wherefore having met with a couple of plauſible objections, ſtarted ſince the death of *Sennertus*, againſt the admitting them at all, we ſhall here briefly examine them, not only to make them appear not to be cogent, but becauſe ſome of our anſwers may ſerve for reaſons, why we admit the forms diſputed of.

THE firſt argument we are to conſider is, that a body can have but one form, being but one body.

BUT though to this I might frame an anſwer from the looſe and indeterminate ſignification of the word form, yet it may be directly replied, that though a body can have but one total and adequate form, yet nothing hinders but that its parts may have their partial forms ſubordinate to that: as the ſteel-ſpring and the braſs-wheels of a watch may retain their diſtinct metalline forms, though the watch they compoſe be but one. And it is not wholly to be pretermitted on this occaſion, that among the ſchoolmen themſelves there has long been a conſiderable party, who aſſerted with many of the ancients, that in compounded bodies the elements retained their reſpective forms, notwithſtanding the new form, that belonged to the mixed body as ſuch.

SECONDLY, It is objected againſt the ſupervening of a higher form, that a body being already complete in its own kind by its own form, no other form can accrue to it, without making that, which they call *Ens per accidens*.

To this I anſwer, that the notion of an *Ens per accidens* belongs rather to metaphyſicks than natural philoſophy; and in what its eſſence conſiſts, is ſtill ſo hotly diſputed among the moderns, that till the buſineſs be agreed on, or at leaſt more clearly ſtated, an argument drawn from thence will not much preſs us. And indeed when I conſider, that the ſchools themſelves are fain to allow the ſoul and the body, that is, an immaterial ſubſtance and a corporeal, to make up a man, who according to them is *unum per ſe*, and not *per accidens*, and that the ſame ſchools ſcruple not to teach, that the rational ſoul, which is a ſubſtance, and the underſtanding and will, which are ſaid to be its faculties, and ſo its accidents, to make *unum per ſe*; I cannot but think, that, by a parity of reaſon, that name, predicate, or qualification, may well be taken in as large a ſenſe, as is requiſite for our purpoſe. And indeed if the parts of a body, whether merely natural or factitious, be by their union or conjunction brought to become the principle of a property or operation, which belongs to neither of them ſingle; I ſee not, why ſuch a body may not paſs for *unum per ſe*, as well as divers bodies, that are wont to be looked upon under that notion. But to proceed to our further anſwer, not here to urge, that a whole ſect of the Peripateticks themſelves maintained (as we newly noted) the forms of the elements to remain in the mixed body, which notwithſtanding they hold to be very conſiſtent with the unity or oneneſs of that compounded body, it may be anſwered

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anſwered further, that though a body by its own form be complete in its own kind, yet it may be ſuch, as to be capable of being advanced to a nobler ſtate by an acceſſion, that ſhall not ruin its former nature, but enable it to cooperate to nobler actions than its former could reach to. As when a ſpring is made a part of a watch, it does thereby, without loſing the nature of a ſpring, mainly contribute to the nobleſt phænomena of ſo curious an engine; and the ingredients of gun-powder, by the ſuperinduction of the form or new contexture they acquire by being compounded into that concrete, are each of them enobled to cooperate to the performance of things far exceeding the utmoſt it could do before. Nor will it follow from this ſuperinduction of forms, that there may be a form of a form as well as of matter, but only that to a body, that has already a form, an ulterior form may ſupervene, wherein we ſee no abſurdity. But of this point more elſewhere; only in this place it will not be amiſs to take notice, that in our propoſition we thought fit to imploy the words, *ſome bodies*, and, *may be*, becauſe that though in living creatures we may often meet with ſubordinate forms either properly or leſs improperly ſo called, yet that in bodies inanimate this happens not ſo often, you will be induced to think by what you will find ſaid upon the laſt propoſition of this diſcourſe.

VI. THE ſupervening of the new form is often but accidental to the præexiſtent form, and (then) does not at all deſtroy its nature, but modify its operations.

FOR illuſtration ſake, let us conſider a needle, that is not yet touched by a loadſtone: this needle has its own form as a piece of ſteel, as well as its figuration as a needle; but when afterwards it comes to be excited by the loadſtone, there are then new and wonderful properties ſuperinduced, and this needle is able to point regularly north and ſouth, and attract other needles, and communicate a verticity to them, and is fit for much nobler uſes than it was before. And this new modification does ſo regulate its motions, that whereas before it was indifferent, if it were nicely poiſed, to reſt at eaſt and weſt, or at any other point of the compaſs, it is now determined to keep moving till it points north and ſouth, and to reſt in that poſition. And yet by drawing this magnetick needle after a certain manner upon the pole of a vigorous loadſtone, you may in a trice deprive it of all its acceſſional faculties; notwithſtanding which, it will remain as true a ſteel-needle as it was at firſt.

AND perhaps we ſhall need to add but a little reflection on the formerly mentioned inſtance of the ſpring of a watch, to declare intelligibly what it is, that the ſtructure or modification, whence the *forma totius* according to us reſults, does to a body endowed already with its own form. For as the ſpring, though it retain its own nature, and acts according to it, yet by the contrivance of the watch, it is not only ſo pent in, that it cannot fly out to its full extent as elſe it would, but by the ſame contrivance has its inceſſant endeavour to ſtretch it ſelf ſo moderated and managed by the wheels and balance, that it mainly concurs to ſet all the other parts a moving, and perform what is done by a watch as ſuch: ſo in natural bodies, that which is performed by the ſupervening of a higher and total form is, that by virtue of the connection and ſtructure of the parts introduced with this new form, the action of the particular parts, though they retain their own partial forms, and act as far as they can, according to them, is ſo maſtered or otherwiſe modified, that they are brought to concur to thoſe things, that are done by the whole body as one agent, and become ſubſervient to the operations, that are proper to the body in its new and ultimate capacity. So when a piece of lead is without addition vitrified by the meer action of the fire, this happens to the body upon its acquiring the form of glaſs; that whereas before the metalline particles were ſo inconveniently ſituated, and perhaps ſhaped, that they denied paſſage to the beams of light, and by reaſon of their contexture compoſed a body, that was very flexible, they become now to be ſo ranged and otherwiſe altered, that they freely admit the light to traverſe them, but admit not of being freely bent as before. And when ſalt-petre, by the addition of a ſmall proportion of brimſtone and coal, is made into gun-powder, this accrues to it from its acquired modification, that if a little fire fall on it, it will not, as before, leiſurely conſume, and leave behind it a conſiderable portion of the whole body (perhaps a third part or more) in the form of a fixed or alkalizate ſalt, but will fly away all at once, and leave little or nothing behind it.

VII. BESIDES the ſpecifick actions of a body, that harbours ſubordinate forms, there may be divers others, wherein ſome of the parts or ingredients may act according to their particular and priſtine nature.

THIS might be well enough gathered from what we lately delivered, when we ſhewed, that the total and ſpecifick form has not ſuch a dominion over the partial and ſubordinate ones, as the patrons of theſe forms have imagined. For though, by virtue of the modification of the whole, the operations of the parts or ingredients are ſo compounded and guided, and in ſome caſes as it were overruled, as to concur to thoſe operations that belonged to the *totum* as ſuch, and are requiſite to be performed *actione communi*; yet in other reſpects, and as to other purpoſes, as it is not neceſſary that ſuch bodies as we ſpeak of ſhould have their parts intirely under the dominion of the ultimate form, (that is, ſubſervient only to the operations and uſes of the *totum*, as ſuch;) ſo thoſe parts may in ſuch caſes act according to their diſtinct and particular qualifications. This anſwer, I ſay, may be deduced from what has been above delivered; but I chuſe rather to clear the matter by two or three particular inſtances, which may ſhew, that the ſame may happen to ſeveral bodies, that is manifeſt in a watch, where, though the form of the engine do in many things make the ſpring and other parts concur to perform the operations

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tions proper to ſuch an engine, yet the wheels may look bright and yellow, the ſpring may move a magnetick needle freely placed, and other parts may do other things, not by virtue of the form of the watch, but by virtue of their own qualities. An example to this purpoſe may be afforded, by what I remember I have not long ſince mentioned concerning gun-powder. To which I ſhall now add, that whereas in pills and divers other medicines made up of ſeveral ingredients, the *compoſitum* has, if the phyſician do his part well, ſome reſulting virtues diſtinct from thoſe of the ingredients, and belonging to the *compoſitum* as ſuch; it may oftentimes happen, that notwithſtanding the emergent form of the compounded medicine, ſome particular ingredient may not only retain its former nature, but ſo retain it, that the *compoſitum* is endowed with that quality only upon the ſcore of that ingredient. This I have divers times obſerved in certain pills, wherein good ambergreaſe, being mingled with ſome purgative ingredients, retained its own grateful ſmell, and communicated it to the whole maſs, whereof the pills are made: and the moſt ſort of purging pills in our apothecaries ſhops taſte ſtrong of the aloes, whatever the other ingredients be. And a further inſtance (and that a conſiderable one) we may take from treacle, that hath not been too long kept. For though it be acknowledged, that opium works by a ſpecifick, and, as they call it, occult quality, and though it be in (*Venice*) treacle blended with above threeſcore other ingredients, moſt of which enter that famous compoſition in far greater quantity than does the opium; yet in ſpite of the *forma compoſiti*, which ſo elaborate a mixture produces, and to which ſuch great peculiar virtues are aſcribed by Peripatetick as well as other phyſicians, yet it is noted by many, that before treacle grows old, it manifeſtly derives an opiate quality from the little opium admitted in it, and upon that account is a potent remedy in fluxes, and divers other diſtempers, where quieting medicines are proper. A no leſs evident example to our purpoſe we have in the precipitate of gold and mercury, made by heat alone. For though by virtue of the union of the ingredients the reſulting powder may have divers qualities, as particularly, a red colour, which neither the gold nor the quickſilver had apart; yet the ſalivating faculty, which this precipitate uſually, though not always, exerciſes, though it be reckoned among occult qualities, as not having by any been deduced from the firſt or ſecond, yet it belongs to this medicine barely upon the account of the mercurial ingredient: the gold, without that, having no ſuch faculty, and mercury alone without gold being ſufficient (by more ways than one of application) to cauſe a flux of ſpittle.

VIII. IN divers bodies, that which is called or looked upon as the ſpecifick form, is often not ſo much as the preſiding, but only the eminenteſt.

To make out this, we may take notice of the following particulars. 1. We obſerved above, that the word form has not a ſettled and determinate ſignification, but is imployed arbitrarily enough; ſo that divers bodies, to whom particular forms are uſed to be aſſigned, deſerve not that privilege better than many others, in which (perhaps for want of men's having particularly conſidered them,) they are not wont to conſider any peculiar and diſtinct form. 2dly, We have alſo elſewhere ſhown, that the forms of inanimate bodies (which we here ſpeak of) are wont to be but reſpective things, reſulting from the co-exiſtence of ſuch corpuſcles or parts after ſuch a determinate manner. 3dly, It may likewiſe be remembred, what we have already noted, that it is uſually from ſome particular reſpect, or for a fitneſs to ſome particular uſe, that men aſcribe this or that form to this or that body: as we exemplified in oils, ſalt, *&c.* as well as in watches, burning-glaſſes, and the like. 4thly, To theſe things it will be agreeable, that the nature and fabrick of a body may be ſuch, that it may have a manifold ſtructure (if I may ſo ſpeak) anſwerable to more than one of thoſe reſpects, on whoſe ſcore bodies are denominated, or may be fit for more than one of thoſe uſes; an aptitude for which, when it is found ſingle in another body, is ſufficient to make it be referred to this or that diſtinct kind or claſſis of things corporeal. I cannot in few words expreſs this notion more clearly, and therefore ſhall illuſtrate it by the example of antimonial glaſs: for one, that would make beads or microſcopes with it, would readily find in it fuſibleneſs and tranſparency; which, when they are found in common glaſs or *vitrum Saturni*, are enough to refer them to that ſort of bodies, that are comprehended under the name of glaſs. But beſides this combination, or (if many convene) this conjugation of qualities, or (to expreſs it in one word) beſides this modification, the body we ſpeak of has another, upon whoſe account it is yet to work upwards and downwards in a human body; upon which ſcore, as the artificer conſiders it only as glaſs, ſo the chymiſt and phyſician look upon it as a medicine. 5thly, Nor is it neceſſary, that theſe conjugations of qualities, or (theſe) modifications, ſhould have a ſtrict dependency upon one another; as for inſtance, the emetick and cathartick properties of the antimonial glaſs belong not to it as glaſs, or (if you pleaſe) do not flow immediately from the form it hath of glaſs; for neither has common glaſs, nor (that we know of) glaſs of lead any ſuch properties, nor is it neceſſary, that if this very portion of matter had not the form of glaſs, it ſhould want or loſe theſe properties. For the calx of antimony, before its vitrification, had them; and you may even without addition obtain from this glaſs a regulus, that is not, like glaſs, tranſparent, but looks like a metalline body, under which form it may yet preſerve the virtues of the calcined antimony. 6thly, To theſe things it will alſo be congruous, that ſince, as was ſaid above, the nobleneſs or ignobleneſs of forms is not eaſy to be decided, and is wont to be meaſured by men, by the greater or leſſer uſe, that the eſtimated body affords them, one man may in the ſame body look upon one kind of modification,

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dification, and another upon a quite differing one as the higheſt form of that body. As in the lately mentioned example of the melted calx of antimony, an artificer may think it's nobleſt form to be that of glaſs, and a chymiſt or a phyſician that of antimony. And ſo if an ordinary watch, that ſhows only the hours and their quarters, being hung at a ſtring, were made to ſwing as a pendulum, to an aſtronomer or ſome other, that were to make nice obſervations, it would be moſt uſeful in the capacity of a pendulum, becauſe, as that, it may divide a minute into ſeconds, and a ſecond it ſelf into half or fourth parts: but for other men, who, though they need an inſtrument to meaſure time, need not ſuch minute ſubdiviſions of it, the little engine we ſpeak of will be much more uſeful and conſiderable in the capacity of a watch than of a pendulum. 7thly, From all which particulars it will be reaſonable to collect, that it may often happen in inanimate bodies, whether confeſſedly natural, or ſuch as are called factitious, that that, which is looked upon as the ultimate, or at leaſt the chief form, is not the preſiding, but only the eminenteſt: by which I mean, not ſimply the nobleſt (for that, were hard to determine, and according to men's eſtimates would not be always true) but that, which in that body is at leaſt for the time the moſt conſidered; or, if that expreſſion will pleaſe better, we may ſay, that ſometimes the moſt regarded form is not ſo much the predominating as the denominating form.

IX. THE lately mentioned forms ſeem to be rather concurrent than ſubordinate.

THIS, as I was ſaying, follows well enough from, what has been freſhly diſcourſed. For if a body may have divers ſuch conjugations of accidents or modifications, as may intitle it in differing reſpects to differing forms, and that form, which is conſidered as the eminenteſt be not a preſiding form, nor ſo much as always the nobleſt; what will remain, but that theſe forms (for I have granted above, that ſome bodies may have ſubordinate ones) that happen to coexiſt in the ſame body, be more fitly termed concurrent or coincident than ſubordinate?

AND indeed though I cannot now ſtay to examine, how far what I ſhall ſay may be applied to bodies in general, I confeſs that, as to inanimate bodies, this dominion and ſubjection, that is imagined between forms, ſeems to me, at leaſt in many caſes, neither well eſtabliſhed, nor eaſy to be well explicated. And I doubt, that ſometimes we miſtake names for things; and becauſe when a body by the action of proper agents obtains ſuch a modification, as fits it for ſuch and ſuch actions and uſes, we are wont to call it by ſuch a name, and attribute a form to it, we are prone to conclude, that the faculties and qualifications it enjoys, and the things it is able to perform, are due to this form we have aſſigned it; as if this form were ſome diſtinct and operative ſubſtance, that were put into the body as a boy into a pageant, and did really begin, and guide, and overrule the motions and actions of the *compoſitum*. Whereas indeed what we call the form, if it be not ſometimes little more than one of thoſe airy things, that ſchools call an external denomination, ſeems oftentimes to be rather a metaphyſical conception in our mind than a phyſical agent, that performs all things in the body it is aſcribed to: As when a conveniently ſhaped piece of ſteel is, by having a due temper given it, turned into the ſpring of a watch, not only the motions of the watch, though proceeding from this ſpring, proceed not from the form of the iron (for a ſpring made of another elaſtical body, though it would not be ſo convenient, might ſet a watch a moving) but, which is here the main obſervable, the ſpringineſs it ſelf flows not immediately from the form (for ſteel is not leſs ſteel, when it is not ſpringy than when it is) but from the mechanical and adventitious texture, that is ſuperinduced in the metal, and may be given it by ſeveral outward agents, as the fire, the hammer, *&c.* And it is ſo far from being evident, that in bodies inanimate and compounded the eminenteſt and moſt conſidered form muſt have a dominion over, and an efficacy in all operations and actions of the *compoſitum*, that even in bodies not ſo compounded it is not always neceſſary, that the ſpecifick form ſhould have ſo much as a concurrent ſtroke in what is performed: for external agents may introduce ſuch qualities into the body we ſpeak of, as, being once there, will ſuffice for actions and productions ſuitable to their own nature, whether the form be active in aſſiſting them or no. We ſee, that boiling water taken off the fire will raiſe bliſters on one's hands, and dreſs meat, and perform other things wont to be the effects of the fire, only by virtue of the adventitious heat it has received; though, according to the Peripateticks, the form of water, which is an element naturally cold as well as moiſt, ought rather to oppoſe than further the action of the preternatural heat. Another example to the ſame purpoſe may be given in the operations of a heated iron taken from the fire, (nay, though that be quite put out) to which divers other inſtances might be added. I know it may be pretended in favour of the ſchools, that it is the fire, that was got in, and yet remains in the iron, that was the cauſe of theſe effects. But beſides that this ſubterfuge would involve the makers in very perplexing difficulties, I will, to prevent the allegation, put a caſe, where it cannot be pretended, by ſuppoſing the iron to be heated not by the fire, but by forcible ſtrokes between a hammer and an anvil, both of them actually cold. When a piece of ſilver is by being hammered, or drawn into wire, made to be a ſpringy body, it will be able to act many things by that acquired elaſticity, which do not at all flow from the form peculiar to the metal. For not only copper, ſteel, and many other bodies may be made ſpringy too; but, if you heat it in the fire, the goldſmith will aſſure you, that it is as true and as good ſilver as before, and yet it will ceaſe to be a ſpring. And ſo when a ſmith makes a file, by making in it many little impreſſions acroſs one another, and afterwards hardning the ſteel, by virtue of this roughneſs, which is given it by external agents, it

acquires a durable aſperity, upon whoſe account it is qualified to perform many and conſiderable things, whereto the form of the metal as ſuch does not, that appears, concur. And though the hardneſs contribute to the making a good file, yet not only the iron was as true and perfect iron, before it became rough, as afterwards, but even that degree of hardneſs, which qualifies our inſtrument to be a good file, flows not immediately from the form of the metal, for that was true iron, when it was ſoft, and its eminent degree of hardneſs was (as I freſhly intimated) given it by the temper it received from the ſmith. I could eaſily increaſe the number of theſe inſtances, if it were neceſſary; and I ſhould here add ſome examples to ſhew, that even in occult qualities, which are ſo generally preſumed to flow from the ſpecifick form of a body, it is not always neceſſary, that this form ſhould have any great intereſt (or perhaps any at all) in the operations; but that the matter need but be duely excited, and diſpoſed by outward agents, to be enabled to perform them: this, I ſay, I ſhould here make probable, were it not that ſuch inſtances do more properly belong to our notes about particular, and eſpecially about occult qualities.

BUT that I may at length conclude this diſcourſe, I ſhall now in the cloſe, as I have done in ſome of the paſſages of it, complain, that the uncertain ſignification and uſe of the terms, wont to be imployed about the points I have been handling, are apt to occaſion much darkneſs and difficulty in our inquiries into the things themſelves; and I am apt to think, that if the meaning of the words, *form*, *life*, *ſoul*, *animal*, *vegetative*, and ſome few other terms were clearly defined and agreed on, a great part of the perplexing controverſies, that are agitated about ſubordinate forms, and points relating unto them, would appear to be diſputes about words or terms. And I am not ſure, but that ſome parts of the paſſed diſcourſe would not be looked upon as of the ſame kind too, not out of choice, but a neceſſity impoſed upon me, by the nature of my deſign, that I was drawn to meddle with any controverſy, that I think may hereafter look like a verbal one; ſo if I have not miſſed my aim, I have both diſcovered ſome errors and deficiencies in the received doctrine I took upon me to conſider, and contributed ſomething towards the future eſtabliſhing of a clearer, as well as truer theory about theſe matters.

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A way of preſerving BIRDS taken out of the EGG, and other ſmall FOETUS's.

Firſt Printed in the *Philoſophical Tranſactions*, N°. XII. p. 199. For *Monday* May 7. 1666.

THIS was imparted in a letter, as follows, The time of the year invites me to intimate to you, that among the other uſes of the experiment, I long ſince preſented the ſociety of preſerving whelps taken out of the dam's womb, and other *fœtus's*, or parts of them, in ſpirit of wine; I remember I did, when I was ſolicitous to obſerve the proceſs of nature in the formation of a chick, open hen's eggs, ſome at ſuch a day, and ſome at other days after the beginning of the incubation; and carefully taking out the embryos, embalmed each of them in a diſtinct glaſs (which is to be carefully ſtopt) in ſpirit of wine. Which I did, that ſo I might have them in readineſs to make on them, at any time, the obſervations I thought them capable of affording; and to let my friends at other ſeaſons of the year ſee, both the differing appearances of the chick at the third, fourth, ſeventh, fourteenth, or other days, after the eggs had been ſat on, and (eſpecially) ſome particulars not obvious in chickens, that go about; as the hanging of the guts out of the abdomen, *&c.* How long the tender embryo of the chick ſoon after the *punctum ſaliens* is diſcoverable, and whilſt the body ſeems but a little organized gelly, and ſome while after that, will be this way preſerved, without being too much ſhriveled up, I was hindered by ſome miſchances to ſatisfy my ſelf: but when the fœtus's I took out, were ſo perfectly formed, as they were wont to be about the ſeventh day, and after, they ſo well retained their ſhape and bulk, as to make me not repent of my curioſity; and ſome of thoſe, which I did very early this ſpring, I can yet ſhew you. I know I have mentioned to you an eaſy application of what I, ſome years ſince, made publick enough; but not finding it to have been yet made by any other, and being perſuaded by experience, that it may be extended to other fœtus's, which this ſeaſon (the ſpring) is time to make proviſion of, I think the advertiſement will not ſeem unſeaſonable to ſome of our friends; though being now in haſte, and having in my thoughts divers particulars, relating to this way of preſerving birds taken out of the egg, and other ſmall fœtus's, I muſt content myſelf to have mentioned that, which is eſſential, leaving divers other things, which a little practice may teach the curious, unmentioned. Notwithſtanding which, I muſt not omit theſe two circumſtances; the one, that when the chick was grown big, before I took it out of the egg, I have (but not conſtantly) mingled with the ſpirit of wine, a little ſpirit of ſal armoniac, made (as I have *elſewhere delivered) by the help of quick lime: which ſpirit I chooſe, becauſe, though it abounds in a ſalt not ſour, but urinous, yet I never obſerved it (how ſtrong ſoever I made it) to coagulate ſpirit of wine. The other circumſtance is, that I uſually found it convenient, to let the little animals I meant to embalm, lie for a little while in ordinary ſpirit of wine, to waſh off the looſer filth, that is wont to adhere to the chick, when taken out of the egg; and then, having put either the ſame kind of ſpirit or better upon the ſame bird, I ſuffered it to ſoak ſome hours (perhaps ſome days, *prò re nata*) therein, that the liquor, having drawn as it were what tincture it could, the fœtus being removed into more pure and well dephlegmed ſpirit of wine, might not diſcolour it, but leave almoſt as limpid, as before it was put in.

An Account of a new kind of BAROSCOPE, which may be called STATICAL; and of ſome Advantages and Conveniences it hath above the MERCURIAL.

Firſt Printed in the *Philoſophical Tranſactions*, N°. XIV. p. 256. For *Monday* July, 2. 1666.

AS for the new kind of baroſcopes, which, not long ago, †I intimated to you, that my haſte would not permit me to give you an account of; ſince your letters acquaint me, that you ſtill deſign a communicating to the curious as much information, as may be, in reference to baroſcopes; I ſhall venture to ſend you ſome account of what I did but name (in my former letter) to you.

THOUGH by a paſſage, you may meet with in the 19th and 20th pages of my thermometrical experiments and thoughts, you may find, that

* In the Uſefulneſs of Experimental Philoſophy.
† See *Numb.* XI. *p.* 185. Phil. Tranſactions.

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that I did ſome years ago think upon this new kind of baroſcope; yet the changes of the atmoſphere's weight not happening to be then ſuch, as I wiſhed, and being unwilling to deprive my ſelf of all other uſe of the exacteſt balance*, that I (or perhaps any man) ever had, I confeſs to you, that ſucceſſive avocations put this attempt for two or three years out of my thoughts; till afterwards returning to a place, where I chanced to find two or three pair of ſcales, I had left there, the ſight of them brought it into my mind; and though I were then unable to procure exacter, yet my deſire to make the experiment ſome amends for ſo long a neglect put me upon conſidering, that if I provided a glaſs-bubble, more than ordinary large and light, even ſuch balances, as thoſe, might in ſome meaſure perform, what I had tried with the ſtrangely nice ones above-mentioned.

I CAUSED then to be blown at the flame of a lamp, ſome glaſs-bubbles, as large, thin and light, as I could then procure; and chuſing among them one, that ſeemed the leaſt unfit for my turn, I counterpoiſed it in a pair of ſcales, that would loſe their æquilibrium with about the 30th part of a grain, and were ſuſpended at a frame. I placed both the balance and the frame by a good baroſcope, from whence I might learn the preſent weight of the atmoſphere. Then leaving theſe inſtruments together; though the ſcales, being no nicer than I have expreſſed, were not able to ſhew me all the variations of the air's weight, that appeared in the mercurial baroſcope, yet they did what I expected, by ſhewing me variations no greater than altered the height of quick-ſilver half a quarter of an inch, and perhaps much ſmaller, than thoſe: nor did I doubt, that, if I had had either tender ſcales, or the means of ſupplying the experiment with convenient accommodations, I ſhould have diſcerned far ſmaller alterations of the weight of the air, ſince I had the pleaſure to ſee the bubble ſometimes in an æquilibrium with the counterpoiſe; ſometimes, when the atmoſphere was high, preponderate ſo manifeſtly, that the ſcales being gently ſtirred, the cock would play altogether on that ſide, at which the bubble was hung; and at other times (when the air was heavier) that, which was at the firſt but the counterpoiſe, would preponderate, and, upon the motion of the balance, make the cock vibrate altogether on its ſide. And this would continue ſometimes many days together, if the air ſo long retained the ſame meaſure of gravity; and then (upon other changes) the bubble would regain an æquilibrium, or a preponderance: ſo that I had oftentimes the ſatisfaction, by looking firſt upon the ſtatical baroſcope (as for diſtinction's ſake it may be called) to foretel, whether in the mercurial baroſcope the liquor were high or low. Which obſervations, though they hold as well in winter, and ſeveral times in ſummer (for I was often abſent during that ſeaſon) as the ſpring, yet the frequency of their viciſſitudes (which perhaps was but accidental) made them more pleaſant in the latter of theſe ſeaſons.

So that, the matter of fact having been made out by variety of repeated obſervations, and by ſometimes comparing ſeveral of thoſe new baroſcopes together, I ſhall add ſome of theſe notes about this inſtrument, which readily occur to my memory, reſerving the reſt to another opportunity.

AND firſt, if the ground, on which I went in framing this baroſcope, be demanded, the anſwer in ſhort may be; 1. That though the glaſs-bubble, and the glaſs-counterpoiſe, at the time of their firſt being weighed, be in the air, wherein they both are weighed, exactly of the ſame weight; yet they are nothing near of the ſame bulk; the bubble, by reaſon of its capacious cavity, (which contains nothing but air, or ſomething that weighs leſs than air) being perhaps a hundred or two hundred times (for I have not conveniency to meaſure them) bigger than the metalline counterpoiſe. 2. That according to a hydroſtatical law, (which you know I have lately had occaſion to make out) if two bodies of equal gravity, but unequal bulk, come to be weighed in another medium, they will be no longer equiponderant; but if the new medium be heavier, the greater body, as being lighter in ſpecie, will loſe more of its weight, than the leſſer and more compact; but if the new medium be lighter than the firſt, then the bigger body will out-weigh the leſſer: and this diſparity, ariſing from the change of mediums, will be ſo much the greater, by how much the greater inequality of bulk there is between the bodies formerly equiponderant. 3. That laying theſe two together, I conſidered, that it would be all one, as to the effect to be produced, whether the bodies were weighed in mediums of differing gravity, or in the ſame medium, in caſe its (ſpecifick) gravity were conſiderably altered: and conſequently, that ſince it appeared by the baroſcope, that the weight of the air was ſometimes heavier and ſometimes lighter, the alterations of it, in point of gravity, from the weight, it was of at firſt counterpoiſing of the bubble of it, would unequally affect ſo large and hollow a body, as the bubble, and ſo ſmall and denſe a one, as a metalline weight: and when the air, by an increaſe of gravity, ſhould become a heavier medium than before, it would buoy up the glaſs more than the counterpoiſe; and if it grew lighter than it was at firſt, would ſuffer the former to preponderate. (The illuſtrations and proof can ſcarce be added in few words; but if it be deſired, I may, God permitting, ſend you them at my next leiſure.) And though our Engliſh air be about a thouſand times lighter than water, the difference in weight of ſo little air, as is but equal in bulk to a bubble, ſeemed to give ſmall hopes, that it would be ſenſible upon a balance; yet, by making the bubble very large and light, I ſuppoſed and found the event, I have already related.

SECONDLY, The hermetically ſealed glaſs-bubble I employed, was of the bigneſs of a ſomewhat large orange, and weighed about 1 drachm and 10 grains. But I thought it very poſſible,

* The ſcales here meant were before competent eye-witneſſes made to turn manifeſtly with the thouſandth part of a grain.

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poſſible, if I had been better furniſhed with conveniences (wherein I afterwards found, I was not miſtaken) to make among many, that might be expected to miſcarry, ſome, that might be preferable to this, either for capacity or lightneſs, or both; eſpecially if care be taken, that they be not ſealed up, whilſt they are too hot. For, though one would think, that it were advantageous to rarify and drive out the air as much as is poſſible, becauſe in ſuch ſealed bubbles the air itſelf (as I have elſewhere ſhewn) has a weight; yet this advantage countervails not the inconvenience of being obliged to increaſe the weight of the glaſs, which, when it includes highly rarified air, if it be not ſomewhat ſtrong, will be broken by the preſſure of the external air, as I have ſufficiently tried.

THIRDLY, I would have tried, whether the dryneſs and moiſture of the air would in any meaſure have altered the weight of the bubble, as well as the variation of gravity produced in the atmoſphere by other cauſes; but the extraordinarily conſtant abſence of fogs kept me from making obſervations of this kind; ſave that one morning early, being told of a miſt, I ſent to ſee (being my ſelf in bed) whether it made the air ſo heavy as to buoy up the bubble; but did not learn, that that miſt had any ſenſible operation on it.

FOURTHLY, By reaſon of the difficulties and caſualties, that may happen about the procuring and preſerving ſuch large and light bubbles, as I have been lately mentioning; it may in ſome caſes prove a convenience to be informed, that I have ſometimes, inſtead of one ſufficiently large bubble, made uſe of two, that were ſmaller. And though a ſingle bubble of competent bigneſs be much preferable, by reaſon that a far leſs quantity and weight of glaſs is requiſite to compriſe an equal capacity, when the glaſs is blown into a ſingle bubble, than when it is divided into two; yet I found, that the imploying of two inſtead of one, did not ſo ill anſwer my expectations, but that they may for a need ſerve the turn inſtead of the other; than which they are more eaſily to be procured. And if the balance be ſtrong enough to bear ſo much glaſs, without being injured, by imploying two or a greater number of larger bubbles, the effect may be more conſpicuous, than if only a ſingle bubble (though a very good one) were imployed.

THIS inſtrument may be improved by divers accommodations. As

FIRST, There may be fitted to the anſa (or cheeks of the balance) an arch (of a circle) divided into 15 or 20 degrees, (more or leſs, according to the goodneſs of the balance) that the cock reſting over againſt theſe diviſions, may readily and without calculation ſhew the quantity of the angle, by which, when the ſcales propend either way, the cock declines from the perpendicular, and the beam from its horizontal paralleliſm.

SECONDLY, Thoſe, that will be ſo curious, may, inſtead of the ordinary counterpoiſe, (of braſs) imploy one of gold, or at leaſt of lead, whereof the latter being of equal weight with braſs, is much leſs in bulk, and the former amounts not to half its bigneſs.

THIRDLY, Theſe parts of the balance, that may be made of copper or braſs, without any prejudice to the exactneſs, will, by being made of one of thoſe metals, be leſs ſubject than ſteel, (which yet, if well hardened and poliſhed, may laſt good a great while) to ruſt with long ſtanding.

FOURTHLY, Inſtead of the ſcales, the bubble may be hung at one end of the beam, and only a counterpoiſe to it at the other, that the beam may not be burthened with unneceſſary weight.

FIFTHLY, The whole inſtrument, if placed in a ſmall frame, like a ſquare lanthorn with glaſs-windows, and a hole at the top for the commerce of the internal and external air, will be more free from duſt, and irregular agitations; to the latter of which, it will otherwiſe be ſometimes incident.

SIXTHLY, This inſtrument being accommodated with a light wheel and an index (ſuch as have been applied by the excellent Dr. *Chriſtopher Wren* to open weather-glaſſes, and by the ingenious Mr. *Hook* to baroſcopes) may be made to ſhew much more minute variations, than otherwiſe.

SEVENTHLY, And the length of the beam, and exquiſiteneſs of the balance, may eaſily, without any of the foregoing helps (and much more with them) make the inſtrument far exacter, than any of thoſe, I was reduced to imploy. And to theſe accommodations divers others may be ſuggeſted, by a farther conſideration of the nature of the thing, and a longer practice.

THOUGH in ſome reſpects this ſtatical baroſcope be inferiour to the mercurial; yet in others it has its own adwantages and conveniences above it.

AND, 1. It confirms *ad oculum* our former doctrine, that the falling or riſing of the mercury depends upon the varying weight of the atmoſphere; ſince in this baroſcope it cannot be pretended, that a *fuga vacui*, or *funiculus*, is the cauſe of the changes, we obſerve. 2. It ſhews, not only that the air has weight, but a more conſiderable one, than ſome learned men, who will allow me to have proved, it has ſome weight, will admit; ſince even the variation of weight in ſo ſmall a quantity of air, as is but equal in bulk to an orange, is manifeſtly diſcoverable upon ſuch balances, as are none of the niceſt. 3. This ſtatical baroſcope will oftentimes be more parable than the other: for many will find it more eaſy to procure a good pair of gold-ſcales, and a bubble or two, than a long cane ſealed, a quantity of quick-ſilver, and all the other requiſites of the mercurial baroſcope; eſpecially if we compriſe the trouble and ſkill, that is requiſite to free the deſerted part of the tube from air. 4. And whereas the difficulty of removing the mercurial inſtrument has kept men from ſo much as attempting to do it, even to neighbouring places; the eſſential parts of the ſcale-baroſcope (for the

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frame is none of them) may very eaſily in a little room be carried, whither one will, without the hazard of being ſpoiled or injured. 5. There is not in ſtatical baroſcopes, as in other, a danger of uncertainty, as to the goodneſs of the inſtruments, by reaſon, that in thoſe the air is, in ſome more, and in ſome leſs perfectly excluded; whereas in thoſe, that conſideration has no place. (And by the way, I have ſometimes, upon this account, been able to diſcover by our new baroſcope, that an eſteemed mercurial one, to which I compared it, was not well freed from air.) 6. It being, as I formerly intimated, very poſſible to diſcover hydroſtatically, both the bigneſs of the bubble, and the contents of the cavity, and the weight and dimenſions of the glaſſy ſubſtance (which together with the included air make up the bubble,) much may be diſcovered by this inſtrument, as to the weight of the air abſolute or reſpective. For, when the quickſilver in the mercurial baroſcope is either very high, or very low, or at a middle ſtation between its greateſt and leaſt height, bringing the ſcale-barometer to an exact æquilibrium, (with very minute diviſions of a grain;) you may, by watchfully obſerving, when the mercury is riſen or fallen juſt an inch, or a fourth, or half an inch, *&c.* and putting in the like minute diviſions of a grain to the lighter ſcale, till you have again brought the balance to an exquiſite æquilibrium; you may, I ſay, determine, what known weight in a ſtatical baroſcope anſwers ſuch determinate altitudes of the aſcending and deſcending quickſilver in the mercurial. And if the balance be accommodated with a divided arch, or a wheel and index, theſe obſervations will aſſiſt you for the future to determine readily, by ſeeing the inclination of the cock or the degree marked by the index, what pollency the bubble hath, by the change of the atmoſphere's weight, acquired or loſt. Some obſervations of this nature I watchfully made, ſometimes putting in a 64th, ſometimes a 32^{d}, ſometimes a 16th, and ſometimes heavier parts of a grain, to the lighter ſcale. But one, that knew not, for what uſes thoſe little papers were, coming to a window, where my baroſcopes ſtood, ſo unluckily ſhook them out of the ſcales, and confounded them, that he robbed me of the opportunity of making the nice obſervations I intended, though I had the ſatisfaction of ſeeing, that they were to be made. 7. By this ſtatical inſtrument we may be aſſiſted to compare the mercurial baroſcopes of ſeveral places (though never ſo diſtant) and to make ſome eſtimates of the gravities of the air therein. As if, for inſtance, I have found by obſervation, that the bubble, I imploy, (and one may have divers bubbles of ſeveral ſizes, that the one may repair any miſchance, that may happen to another) weighed juſt a drachm, when the mercurial cylinder was at the height of 29$\frac{1}{2}$ inches, (which in ſome places I have found a moderate altitude;) and that the addition of the 16th part of a grain is requiſite to keep the bubble in an æquilibrium, when the mercury is riſen an 8th, or any determinate part of an inch, above the former ſtation: when I come to another place, where there is a mercurial barometer, as well freed from air as mine (for that muſt be ſuppoſed) if taking out of my ſcale inſtrument, it appear to weigh preciſely a drachm, and, the mercury in the baroſcope there ſtand at juſt 29$\frac{1}{2}$ inches, we may conclude the gravity of the atmoſphere not to be ſenſibly unequal in both thoſe two places, though very diſtant. And though there be no baroſcope there, yet if there be an additional weight, as for inſtance, the 16th part of a grain requiſite to be added to the bubble, to bring the ſcales to an æquilibrium, it will appear, that the air at this ſecond place is, at that time, ſo much heavier, than the air of the former place was, when the mercury ſtood at 29$\frac{1}{2}$ inches.

But in making ſuch compariſons, we muſt not forget to conſider the ſituation of the ſeveral places, if we mean to make eſtimates not only of the weight of the atmoſphere, but of the weight and denſity of the air. For, though the ſcales will ſhew (as has been ſaid) whether there be a difference of weight in the atmoſphere at the two places; yet, if one of them be in a vale or bottom, and the other on the top or ſome elevated part of a hill, it is not to be expected, that the atmoſphere in this latter place ſhould gravitate as much, as the atmoſphere in the former, on which a longer pillar of air does lean or weigh.

And the mention, I have made of the differing ſituation of places, puts me in mind of ſomething, that may prove another uſe of our ſtatical baroſcope, and which I had thoughts of making trial of, but was accidentally hindered from the opportunity of doing it; namely, that by exactly poiſing the bubble at the foot of a high ſteeple or hill, and carrying it in its cloſe frame to the top, one may, by the weight requiſite to be added to counterpoiſe there, to bring the beam to its horizontal poſition, obſerve the difference of the weight of the air at the bottom, and at the top; and, in caſe the hill be high enough, at ſome intermediate ſtations. But how far this may aſſiſt men, to eſtimate the abſolute or comparative height of mountains, and other elevated places; and what other uſes the inſtrument may be put to, when it is duly improved; and the cautions, that may be requiſite in the ſeveral caſes, that ſhall be propoſed, I muſt leave to more leiſure, and farther conſideration.

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A New FRIGORIFICK EXPERIMENT,

SHEWING

How a conſiderable degree of COLD may be ſuddenly produced without the help of SNOW, ICE, HAIL, WIND, or NITRE, and that at any time of the year.

Firſt Printed in the *Philoſophical Tranſactions*, N°. XV. *p.* 255.
For *Wedneſday* July 18, 1666.

AS for the experiment, you ſaw the other day at my lodgings, though it belongs to ſome papers about cold, that (you know) could not be publiſhed, when the reſt of the hiſtory came forth, and therefore was reſerved for the next edition of that book; yet the weather having been of late very hot, and threatning to continue ſo, I preſume, that to give you here, in compliance with your curioſity, an account of the main and practical part of the experiment, may enable you to gratify not only the curious among your friends, but thoſe of the delicate, that are content to purchaſe a coolneſs of drinks at a ſomewhat chargeable rate.

You may remember, that the ſpring before the laſt, I ſhewed you a particular account of a way, wherein by a certain ſubſtance obtained from ſal armoniac, I could preſently produce a conſiderable degree of cold, and that with odd circumſtances, without the help of ſnow, ice, nitre, *&c.* But that experiment being difficult and coſtly enough, and deſigned to afford men information, not accommodations, I afterwards tried, what ſome more cheap and facile mixtures of likely bodies with ſal armoniac would do towards the production of cold, and afterwards I began to conſider, whether to that purpoſe alone (for my firſt experiment was deſigned to exhibit other phænomena too) thoſe mixtures might not without inconvenience be omitted. And I was much confirmed in my conjecture by an accident, which was caſually related to me by a very ingenious phyſician of my acquaintance, but not to be repeated to you in a few words, though he complained, he knew not what to make of it.

AMONG the ſeveral ways, by which I have made infrigidating mixtures with ſal armoniac, the moſt ſimple and facile is this: take one pound of powdered ſal armoniac and about three pints (or pounds) of water; put the ſalt into the liquor, either all together, if your deſign be to produce an intenſe, though but a ſhort coldneſs; or at two, three, or four ſeveral times, if you deſire, that the produced coldneſs ſhould rather laſt ſomewhat longer than be ſo great. Stir the powder in the liquor with a ſtick or whalebone, (or ſome other thing, that will not be injured by the fretting brine, that will be made) to haſten the diſſolution of the ſalt; upon the quickneſs of which, depends very much the intenſity of the cold, that will enſue upon this experiment. For the clearing up whereof, I ſhall annex the following particulars.

1. THAT a conſiderable degree of cold is really produced by this operation, is very evident: Firſt, to the touch; Secondly, by this, that if you make the experiment (as for this reaſon I ſometimes chuſe to do) in a glaſs-body or a tankard, you may obſerve, that, whilſt the ſolution of the ſalt is making, the outſide of the metalline veſſel will, as high as the mixture reaches within, be bedewed (if I may ſo ſpeak) with a multitude of little drops of water, as I have *elſewhere ſhown, that it happens, when mixtures of ſnow and ſalt, being put into glaſſes or other veſſels, the aqueous vapours, that ſwim to and fro in the air, and chance to glide along the ſides of the veſſels, are by the coldneſs thereof condenſed into water. And in our armoniac ſolution you may obſerve, that if you wipe off the dew from any particular part of the outſide of the veſſel, whilſt the ſolution does yet vigorouſly go on, it will quickly collect freſh dew, which may be ſometimes copious enough to run down the ſides of the veſſel. But thirdly, the beſt and ſureſt way of finding out the coldneſs of our mixture is that, which I ſhewed you, by plunging into it a good ſealed weather-glaſs furniſhed with tincted ſpirit of wine. For, the ball of this being put into our frigorifick mixture, the crimſon liquor will nimbly enough deſcend much lower, than when it was kept in the open air, in common water, of the ſame temper with that, wherein the ſal armoniac was put to diſſolve. And if you remove the glaſs out of the mixture into common water, the tincted ſpirit will, (as you may remember it did) haſtily enough re-aſcend for a pretty while, according to the greater or leſſer time, that it continued in the armoniac ſolution. And this has ſucceeded with me, when inſtead of removing the mixture into common water, I removed it into water newly impregnated with ſalt-petre.

THE duration of the cold, produced by this experiment, upon ſeveral circumſtances; as, firſt, upon the ſeaſon of the year, and preſent temperature of the air; for in ſummer

* In the *Hiſtory of Cold*.

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mer and hot weather the cold will ſooner decay and expire. Secondly, upon the quantity of the ſalt and water: for, if both theſe be great, the effect will be as well more laſting, as more conſiderable. Thirdly, for aught I yet know, we may here add the goodneſs and fitneſs of the particular parcel of ſalt, that is imployed: for though it be hard to diſcern beforehand, which will be the more, and which the leſs proper; yet ſome trials have tempted me to ſuſpect, that there may be a conſiderable diſparity, as to their fitneſs to produce cold, betwixt parcels of ſalt, that are without ſcruple looked upon as ſal armoniac; of which difference it were not perhaps very difficult to aſſign probable reaſons from the nature of the ingredients of this compound concrete, and the ways of preparing it. But the duration of the cold may be conceived to depend alſo, fourthly, upon the way of puting the ſalt into the water; for, if you caſt it in all at once, the water will ſooner acquire an intenſe degree of coldneſs, but it will alſo the ſooner return to its former temper; whereas, if you deſire but an inferiour degree of quality, but that may laſt longer, (which will uſually be the moſt convenient for the cooling of drinks,) then you may put in the ſalt by little and little. For, keeping a long weather-glaſs for a good while in our impregnated mixture, I often purpoſely tried, that, when the tincted liquor ſubſided but ſlowly, or was at a ſtand, by putting in, from time to time, 2 or 3 ſpoonfuls of freſh ſalt, and ſtirring the water to quicken the diſſolution, the ſpirit of wine would begin again to deſcend, if it were at a ſtand, or riſing, or ſubſide much more ſwiftly than it did before. And if you would lengthen the experiment, it may not be amiſs, that part of the ſal armoniac be but groſly beaten, that it may be the longer in diſſolving, and conſequently in cooling the water. Whilſt there are dewy drops produced on the outſide of the veſſel, it is a ſign, that the cold within continues pretty ſtrong; for, when it ceaſes, theſe drops eſpecially in warm weather, will by degrees vaniſh. But a ſurer way of meaſuring the duration of the cold, is, by removing from time to time the ſealed weather-glaſs out of the ſaline mixture into the ſame common water, with part of which it was made. And though it be not eaſy to determine any thing particularly about this matter, yet it may ſomewhat aſſiſt you in your eſtimates, to be informed, that I have in the ſpring by a good weather-glaſs found a ſenſible adventitious cold, made by a pound of ſal armoniac at the utmoſt, to laſt about two or three hours.

3. To cool drinks with this mixture, you may put them in thin glaſſes, the thinner the better; which (their orifices being ſtopped, and ſtill kept above the mixture) may be moved to and fro in it, and then be immediately poured out to be drunk: though when the glaſs, I imployed, was conveniently ſhaped, as like a ſugar-loaf, or with a long neck, I found it not amiſs to drink it out of that, without pouring it into any other; which can ſcarce be done without leſſening the coldneſs. The refrigeration, if the glaſs-phial be convenient, is quickly performed: and if one have a mind to cool his hands, he may readily do it, by applying them to the outſide of the veſſel, that contains the refrigerating mixture; by whoſe help, pieces of cryſtal, or bullets for the cooling of the mouths or hands of thoſe patients, to whom it may be allowed, may be potently cooled, and other ſuch refreſhments may be eaſily procured.

4. How far ſal armoniac, mingled with ſand or earth, and not diſſolved, but only moiſtned with a little water ſprinkled on it, will keep bottles of wine or other liquors more cool, than the earth or that ſand alone will do, I have not yet had opportunity by ſufficient trials fully to ſatisfy my ſelf, and therefore reſign that inquiry to the curious.

5. For the cooling of air, and liquors, to adjuſt weather-glaſſes, to be able to do which, at all times of the year, was one of the chief aims, that made me bethink my ſelf of this experiment; or to give a ſmall quantity of beer, *&c.* a moderate degree of coolneſs, it will not be requiſite, to imploy near ſo much as a whole pound of ſal armoniac at a time. For you may eaſily obſerve by a ſealed weather-glaſs, that a very few ounces, well powdered and nimbly diſſolved in about four times the weight of water, will ſerve well enough for many purpoſes.

6. And that you may the leſs ſcruple at this, I ſhall tell you, that even before and after midſummer, I have found the cold producible by our experiment to be conſiderable, and uſeful for refrigerating of drinks, *&c.* but if the ſal armoniac be of the fitteſt ſort, (for I intimated above, that I ſuſpected, it is not equally good) and if the ſeaſon of the year do make no diſadvantageous difference, the degree of cold, that may be produced by no more than one pound (if not by leſs) ſal armoniac, may within its own ſphere of activity, be much more vehement, than, I preſume, you yet imagine, and may afford us excellent ſtandards to adjuſt ſealed weather-glaſſes by; and for ſeveral other purpoſes. For I remember, that in the ſpring, about the end of *March*, or beginning of *April*, I was able with one pound of ſal armoniac, and a requiſite portion of water, to produce a degree of cold much greater, than was neceſſary the preceding winter, to make it froſty weather abroad; nay, I was able to produce ice in a ſpace of time, almoſt incredibly ſhort. To confirm which particulars, becauſe they will probably ſeem ſtrange to you, I will here annex the tranſcript of an entry, that I find in a note-book of phænomena and ſucceſs of one of thoſe experiments, as I then tried it; though I ſhould be aſhamed to expoſe to your peruſal a thing ſo rudely penned, if I did not hope, you would conſider, that it was haſtily written only for my own remembrance. And that you may not ſtop at any thing in the immediately annext note, or the two that follow, it will be requiſite to premiſe this account

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count of the ſealed thermoſcope, (which was a good one) wherewith theſe obſervations were made; that the length of the cylindrical pipe was 16 inches; the ball, about the bigneſs of a ſomewhat large walnut, and the cavity of the pipe by gueſs about an eighth or ninth part of an inch diameter.

THE firſt experiment is thus regiſtered. *March* the 27th, in the ſealed weather-glaſs, when firſt put into water, the tincted ſpirit reſted at $8\frac{5}{8}$ inches: being ſuffered to ſtay there a good while, and now and then ſtirred to and fro in the water, it deſcended at length a little beneath $7\frac{5}{8}$ inches: then the ſal armoniac being put in, within about a quarter of an hour, or a little more, it deſcended to $2\frac{11}{16}$ inches, but before that time, in half a quarter of an hour it began manifeſtly to freeze the vapours and drops of water on the outſide of the glaſs. And when the frigorifick power was arrived at the height, I ſeveral times found, that water, thinly placed on the outſide, whilſt the mixture within was nimbly ſtirred up and down, would freeze in a quarter of a minute, (by a minute watch.) At about $\frac{3}{4}$ of an hour after the infrigidating body was put in, the thermoſcope, that had been taken out a while before, and yet was riſen but to the loweſt freezing mark, being again put in the liquor, fell an inch beneath the mark. At about $2\frac{1}{2}$ hours from the firſt ſolution of the ſalt I found the tincted liquor to be in the midſt between the freezing marks, whereof the one was at $5\frac{1}{2}$ inches (at which height when the tincture reſted, it would uſually be ſome, though but a ſmall froſt abroad;) and the other at $4\frac{3}{4}$ inches; which was the height, to which ſtrong and durable froſts had reduced the liquor in the winter. At three hours after the beginning of the operation, I found not the crimſon-liquor higher than the upper freezing mark newly mentioned; after which, it continued to riſe very ſlowly for about an hour longer; beyond which time I had not occaſion to obſerve it.

THUS far the note-book; wherein there is mention made of a circumſtance of ſome former experiments of the like kind, which I remember was very conſpicuous in this newly recited. For, the frigorifick mixture having been made in a glaſs-body (as they call it) with a large and flattiſh bottom, a quantity of water, which I (purpoſely) ſpilt upon the table, was, by the operation of the mixture within the glaſs, made to freeze, and that ſtrongly enough, the bottom of the cucurbite to the table; that ſtagnant liquor being turned into ſolid ice, that continued a conſiderable while unthawed away, and was in ſome places about the thickneſs of a half-crown piece.

ANOTHER obſervation, made the ſame ſpring, but leſs ſolemn, as meant chiefly to ſhew the duration of cold in a high degree, is recorded in theſe terms: The firſt time, the ſealed weather-glaſs was put in, before it touched the common water, it ſtood at $8\frac{5}{8}$, having been left there a conſiderable while, and once or twice agitated the water, the tincted liquor ſunk but to $7\frac{7}{8}$, or at furtheſt, $7\frac{6}{8}$; then the frigorifick liquor being put into the water with circumſtances diſadvantageous enough, in (about) half a quarter of an hour the tincted liquor fell beneath $3\frac{3}{4}$; and the thermoſcope being taken out, and then put in again, an hour after the water had been firſt infrigidated, ſubſided beneath 5 inches, and conſequently within $\frac{1}{4}$ of an inch of the mark of the ſtrongly freezing weather.

7. WHEREAS the grand thing, that is like to keep this experiment from being as generally uſeful, as perhaps it will prove luciferous, is the dearneſs of ſal armoniack, two things may be offered to leſſen this inconvenience. For firſt, ſal armoniac might be made much cheaper, if inſtead of fetching it beyond ſea our country-men made it at home; which it may eaſily be, and I am ready to give you the receipt, which is no great ſecret. But next I conſidered, that probably the infrigidating virtue of our mixture might depend upon the peculiar texture of the ſal armoniac, whereby, whilſt the water is diſſolving it, either ſome frigorific particles are extricated and excited, or rather ſome particles, which did before more agitate the minute parts of the water, are expelled (or invited out by the ambient bodies) or come to be clogged in their motion: whence it ſeemed reaſonable to expect, that upon the re-union of the ſaline particles into ſuch a body, as they had conſtituted before, the redintegrated ſal armoniac, having near upon, the ſame texture, would, upon its being rediſſolved produce the ſame, or a not much inferiour degree of coldneſs: And hereupon, though I well enough foreſaw, that an armoniac ſolution, being boiled up in earthen veſſels (for glaſs ones are too chargeable) would, by piercing them, both loſe ſome of the more ſubtile parts, and thereby ſomewhat impair the texture of the reſt; yet I was not deceived in expecting, that the dry ſalt, remaining in the pipkins, being rediſſolved in a due proportion of water, would very conſiderably infrigidate it; as may further appear by the notes, which for your greater ſatisfaction you will find here ſubjoined, as ſoon as I have told you, that, though for want of other veſſels I was firſt reduced to make uſe of earthen ones, and the rather, becauſe ſome metalline veſſels will be injured by the diſſolved ſal armoniac, if it be boiled in them; yet I afterwards found ſome conveniencies in veſſels of other metal, as of iron; whereof you may command a farther account.

March the 29th, the thermoſcope in the air was at $8\frac{7}{8}$ inches; being put into a ſomewhat large evaporating glaſs, filled with water, it fell (after it ſtaid a pretty while, and had been agitated in the liquor) to 8 inches: then about half the ſalt, or leſs, that had been uſed twice before, and felt much leſs cold than the water, being put in and ſtirred about, the tincted ſpirit ſubſided with a viſible progreſs, till it was fallen manifeſtly beneath 4 inches; and then, having cauſed ſome water to be freſhly pumped and brought in, though the newly mentioned ſolution were mixt with it, yet it preſently made the ſpirit of wine manifeſtly to aſcend in the inſtrument, much faſter than one would have expected, &c.

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AND thus much may ſuffice for this time concerning our frigorifick experiment; which I ſcarce doubt but the *Carteſians* will lay hold on as very favourable to ſome of their tenets; which you will eaſily believe, it is not to the opinion, I have elſewhere oppoſed, of thoſe modern philoſophers, that would have ſalt-petre to be the *primum frigidum*: (though I found by trial, that whilſt it is actually diſſolving, it gives a much conſiderabler degree of cold, than otherwiſe.) But about the reflections, that may be made on this experiment, and the variations, and improvements, and uſes of it, though I have divers things lying by me; yet, ſince you have ſeen ſeveral of them already, and may command a ſight of the reſt, I ſhall forbear the mention of them here, not thinking it proper, to ſwell the bulk of this letter with them.

The Method obſerved in Transfuſing the Blood out of one Animal into another.

Firſt Printed in the *Philoſophical Tranſactions* N°. XX. *p.* 353. For *Monday*, December 17, 1666.

THIS method was promiſed in the laſt of theſe papers. It was firſt practiſed by Dr. *Lower* in *Oxford*, and by him communicated to the author, who imparted it to the Royal Society, as follows;

FIRST, Take up the carotidal artery of the dog or other animal, whoſe blood is to be transfuſed into another of the ſame or a differing kind, and ſeparate it from the nerve of the eighth pair, and lay it bare above an inch. Then make a ſtrong ligature on the upper part of the artery, not to be united again: but an inch below, *viz.* towards the heart, make another ligature of a running knot, which may be looſened or faſtened as there ſhall be occaſion. Having made theſe two knots, draw two threads under the artery between the two ligatures; and then open the artery, and put in a quill, and tie the artery upon the quill very faſt by thoſe two threads, and ſtop the quill with a ſtick. After this, make bare the jugular vein in the other dog about an inch and a half long; and at each end make a ligature with a running knot, and in the ſpace betwixt the two running knots draw under the vein two threads, as in the other. Then make an inciſion in the vein, and put into it two quills, one into the deſcendant part of the vein, to receive the blood from the other dog and carry it to the heart; and the other quill put into the other part of the jugular vein, which comes from the head, (out of which, the ſecond dog's own blood muſt run into diſhes.) Theſe two quills being put in and tied faſt, ſtop them with a ſtick, till there be occaſion to open them.

ALL things being thus prepared, place the dogs on their ſides towards one another ſo conveinently, that the quill may go into each other; (for the dog's necks cannot be brought ſo near, but that you muſt put two or three ſeveral quills more into the firſt two, to convey the blood from one to another.) After that, unſtop the quill, that goes down into the firſt dog's jugular vein, and the other quill coming out of the other dog's artery; and by the help of two or three other quills, put into each other, according as there ſhall be occaſion, inſert them into one another. Then ſlip the running knots, and immediately the blood runs through the quills, as through an artery, very impetuouſly. And immediately, as the blood runs into the dog, unſtop the other quill, coming out of the upper part of his jugular vein, (a ligature being firſt made about his neck, or elſe his other jugular vein being compreſſed by one's finger;) and let his own blood run out at the ſame time into diſhes, (yet not conſtantly, but according as you perceive him able to bear it) till the other dog begin to cry, and faint, and fall into convulſions, and at laſt die by his ſide.

THEN take out both the quills out of the dog's jugular vein, and tie the running knot faſt, and cut the vein aſunder, (which you may do without harm to the dog, one jugular vein being ſufficient to convey all the blood from the head and upper parts, by reaſon of a large anaſtomoſis, whereby both the jugular veins meet about the larynx.) This done, ſew up the ſkin and diſmiſs him, and the dog will leap from the table, and ſhake himſelf, and run away, as if nothing ailed him.

AND this I have tried ſeveral times, before ſeveral in the univerſities, but never yet upon more than one dog at a time, for want of leiſure, and convenient ſupplies of ſeveral dogs, at once. But when I return, I doubt not but to give you a fuller account, not only by bleeding ſeveral dogs into one, but ſeveral other creatures into one another, as you did propoſe to me, before you left *Oxford*; which will be very eaſy to perform, and will afford many pleaſant, and perhaps not unuſeful experiments.

BUT becauſe there are many circumſtances neceſſary to be obſerved in the performing of this experiment, and that you may better direct any one to do it, without any danger of killing the other dog, that is to receive the other's blood, I will mention two or three.

FIRST, that you faſten the dogs at ſuch a convenient diſtance, that the vein nor artery be not ſtretched; for then, being contracted, they will not admit or convey ſo much blood.

SECONDLY,

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SECONDLY, that you conſtantly obſerve the pulſe beyond the quill in the dog's jugular vein, (which it acquires from the im pulſe of the arterious blood;) for if that fails, then it is a ſign the quill is ſtopt by ſome congealed blood, ſo that you muſt draw out the arterial quill from the other, and with a probe open the paſſage again in both of them, that the blood may have its free courſe again. For this muſt be expected, when the dog, that bleeds into the other, hath loſt much blood, his heart will beat very faintly, and then the impulſe of blood being weaker, it will be apt to congeal the ſooner, ſo that at the latter end of the work you muſt draw out the quill oftener, and clear the passage; if the dog be faint-hearted, as many are, though ſome ſtout fierce dogs will bleed freely and uninterruptedly, till they are convulſed and die. But to prevent this trouble, and make the experiment certain, you muſt bleed a great dog into a little one, or a maſtive into a curr, as I once tried; and the little dog bled out at leaſt double the quantity of his own blood, and left the maſtive dead upon the table; and after he was untied, he ran away, and ſhaked himſelf, as if he had been only thrown into water. Or elſe you may get three or four ſeveral dogs prepared in the ſame manner; and when one begins to fail and leave off bleeding, adminiſter another; and I am confident one dog will receive all their blood, (and perhaps more) as long as it runs freely, till they are left almoſt dead by turns: provided you let out the blood proportionably, as you let it go into the dog, that is to live.

THIRDLY, I ſuppoſe the dog, that is to bleed out into diſhes, will endure it better, if the dogs, that are to be adminiſtered to ſupply his blood, be of near an equal age, and fed alike the day before, that both their bloods may be of a near ſtrength and temper.

THERE are many things I have obſerved upon bleeding dogs to death, which I have ſeen ſince your departure from *Oxford*, whereof I ſhall give you a relation hereafter. In the mean time ſince you were pleaſed to mention it to the Royal Society, with a promiſe to give them an account of this experiment, I could not but take the firſt opportunity to clear you from that obligation, *&c.*

So far this letter; the preſcriptions whereof having been carefully obſerved by thoſe, who were imployed to make the experiment, have hitherto been attended with good ſucceſs; and that not only upon animals of the ſame ſpecies, (as two dogs firſt, and then two ſheep;) but alſo upon ſome of very differing ſpecies, (as a ſheep and a dog; the former emitting, the other receiving.)

NOTE only, that inſtead of a quill, a ſmall crooked thin pipe of ſilver or braſs, ſo ſlender, that the one end may enter into the quill, and having at the other end, that is to enter into the vein and artery, a ſmall knob, for the better faſtening them to it with a thread, will be much fitter than a ſtrait pipe or quill, for this operation; for ſo they are much more eaſy to be managed.

IT is intended, that theſe trials ſhall be proſecuted to the utmoſt variety the ſubject will bear: as by exchanging the blood of old and young, ſick and healthy, hot and cold, fierce and fearful, tame and wild animals, *&c.* and, that not only of the ſame, but alſo of differing kinds. For which end, and to improve this noble experiment, either for knowledge, or uſe, or both, ſome ingenious men have already propoſed conſiderable trials and inquiries; of which perhaps an account will be given hereafter. For the preſent, we ſhall only ſubjoin ſome

Conſiderations about this kind of Experiments.

1. IT may be conſidered in them, that the blood of the emittent animal may, after a few minutes of time, by its circulation, mix and run out with that of the recipient. Wherefore to be aſſured in theſe trials, that all the blood of the recipient is run out, and none left in him but the adventitious blood of the emittent, two or three or more animals (which was alſo hinted in the method above) may be prepared and adminiſtered, to bleed them all out into one.

2. IT ſeems not irrational to gueſs aforehand, that the exchange of blood will not alter the nature or diſpoſition of the animals, upon which it ſhall be practiſed; though it may be thought worth while, for ſatisfaction and certainty, to determine that point by experiments. The caſe of exchanging the blood of animals ſeems not like that of graffing, where the cyon turns the ſap of the ſtock, graffed upon, into its nature; the fibres of the cyon ſo ſtraining the juice, which paſſes from the ſtem to it, as thereby to change it into that of the cyon: whereas in this transfuſion there ſeems to be no ſuch percolation of the blood of animals, whereby that of the one ſhould be changed into the nature of the other.

3. THE moſt probable uſe of this experiment may be conjectured to be, that one animal may live with the blood of another; and conſequently, that thoſe animals, that want blood, or have corrupt blood, may be ſupplied from others with a ſufficient quantity, and of ſuch as is good, provided the transfuſion be often repeated, by reaſon of the quick expence, that is made of the blood.

Trials

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Trials propoſed to Dr. LOWER, To be made by him, for the improvement of transfuſing Blood out of one live Animal into another.

(Promiſed Numb. XX. *p.* 357.)

First Printed in the *Philoſophical Tranſactions*, N° XXII. *p.* 385.
For *Monday*, February 11. 1666.

THE following queries and trials were written long ſince, and read about a month ago in the Royal Society, and do now come forth againſt the author's intention, at the earneſt deſire of ſome learned perſons, and particularly of the worthy doctor, to whom they were addreſſed; who thinks, they may excite and aſſiſt others in a matter, which to be well proſecuted, will require many hands. At the reading of them, the author declared, that of divers of them he thought he could foreſee the events, but yet judged it fit, not to omit them, becauſe the importance of the theories, they may give light to, may make the trials recompence the pains, whether the ſucceſs favour the affirmative or the negative of the queſtion, by enabling us to determine the one or the other upon ſurer grounds, than we could otherwiſe do. And this advertiſement he deſires may be applied to thoſe other papers of his, that conſiſt of queries or propoſed trials.

The Queries themſelves follow.

1. WHETHER by this way of transfuſing blood, the diſpoſition of individual animals of the ſame kind, may not be much altered? (as whether a fierce dog, by being often quite new ſtocked with the blood of a cowardly dog, may not become more tame;) *& vice verſa*, *&c.*

2. WHETHER immediately upon the unbinding the dog, repleniſhed with adventitious blood, he will know and fawn upon his maſter; and do the like cuſtomary things as before? and whether he will do ſuch things better or worſe at ſome time after the operation?

3. WHETHER thoſe dogs, that have peculiarities, will have them either aboliſhed, or at leaſt much impaired by transfuſion of blood? (as whether the blood of a maſtiff, frequently transfuſed into a blood-hound, or a ſpaniel, will not prejudice them in point of ſcent?)

4. WHETHER acquired habits will be deſtroyed or impaired by this experiment? (as whether a dog, taught to fetch and carry, or to dive after ducks, or to ſett, will after frequent and full recruits of the blood of dogs unfit for thoſe exerciſes, be as good at them, as before?)

5. WHETHER any conſiderable change is to be obſerved in the pulſe, urine, and other excrements of the recipient animal, by this operation, or the quantity of his inſenſible tranſpiration?

6. WHETHER the emittent dog, being full fed at ſuch a diſtance of time before the operation, that the maſs of blood may be ſuppoſed to abound with chyle, the recipient dog, being before hungry, will loſe his appetite, more than if the emittent dog's blood had not been ſo chylous? and how long, upon a vein opened of a dog, the admitted blood will be found to retain chyle?

7. WHETHER a dog may be kept alive without eating by the frequent injection of the chyle of another, taken freſhly from the receptacle, into the veins of the recipient dog?

8. WHETHER a dog, that is ſick of ſome diſeaſe chiefly imputable to the maſs of blood, may be cured by exchanging it for that of a ſound dog? and whether a ſound dog may receive ſuch diſeaſes from the blood of a ſick one, as are not otherwiſe of an infectious nature?

9. WHAT will be the operation of frequently ſtocking, (which is feaſible enough) an old and feeble dog with the blood of young ones, as to livelineſs, dulneſs, drowſineſs, ſqueamiſhneſs, *&c. & vice verſa.*

10. WHETHER a ſmall young dog, by being often freſh ſtocked with the blood of a young dog of a larger kind, will grow bigger than the ordinary ſize of his own kind?

11. WHETHER any medicated liquors may be injected together with the blood, into the recipient dog? and, in caſe they may, whether there will be any conſiderable difference found between the ſeparations made on this occaſion, and thoſe, which would be made, in caſe ſuch medicated liquors had been injected with ſome other vehicle, or alone, or taken in at the mouth?

12. WHETHER a purgative medicine, being given to the emittent dog a while before the the operation, the recipient dog will be thereby purged, and how? (which experiment may be hugely varied.)

13. WHETHER the operation may be ſucceſsfully practiſed, in caſe the injected blood be that of an animal of another ſpecies, as of a calf into a dog, *&c.* and of a cold animal, as of a fiſh, or frog, or tortoiſe, into the veſſels of a hot animal? *& vice verſa?*

14. WHETHER the colour of the hair or feathers of the recipient animal, by the frequent repeating of this operation, will be changed into that of the emittent?

15. WHETHER by frequently transfuſing into the ſame dog, the blood of ſome animal of another ſpecies, ſomething further, and more

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tending to ſome degrees of a change of ſpecies, may be effected, at leaſt in animals near of kin; (as ſpaniels and ſetting dogs, Iriſh grey-hounds and ordinary grey-hounds, *&c*?)

16. WHETHER the transfuſion may be practiſed upon pregnant bitches, at leaſt at certain times of their gravidation? and what effect it will have upon the whelps?

THERE were ſome other queries propoſed by the ſame author; as, the weighing of the emittent animal before the operation, that (making an abatement for the effluviums, and for the excrements, if it voids any) it may appear, how much blood it really loſes. To which were annext divers others, not ſo fit to be peruſed but by phyſicians, and therefore here omitted.

PROPOSALS

To try the Effects of the PNEUMATICK ENGINE exhauſted, in Plants, Seeds, Eggs of Silk-worms.

Firſt Printed in the *Philoſophical Tranſactions*, N°. XXIII. p. 424. For *Monday* March 11. 1666.

THE ingenious Dr. *Beale* did formerly ſuggeſt, as follows.

IT would be, I think (ſaith he) very well worth the trial, to ſee what effects would be produced on plants, put into the pneumatick (or rarifying) engine of Mr. *Boyle*, with the earth about their roots, and flouriſhing; whether they would not ſuddenly wither, if the air were totally taken from them. And particularly to try in the ſeaſon cherry-bloſſoms, when partly opened, partly not opened, upon a branch; to wit, whether the air may be ſo attenuated as to blaſt. But it may be noted, that the bloſſoms do not forthwith diſcover the blaſt; an old experienced countryman having once given me notice of a blaſty noon, (it being then ſultry weather, and ſomewhat gloomy with the thickneſs of exhalations, almoſt like a very thick miſt) and within a day or two ſhewing the proof upon the cherry-bloſſoms then flagging, but not much altering their colour till two days more were paſt.

THE noble Mr. *Boyle* ſuggeſts, as proper for the approaching ſeaſon; that it may be tried,

1. WHETHER ſeeds (eſpecially ſuch as are of a haſty growth, *viz.* orpin, lettice, garden-creſs-ſeeds, *&c.*) will germinate and thrive in the exhauſted receiver of the ſaid engine?

2. WHETHER the excluſion of air from the ſenſitive plant would be harmful to it?

3. WHETHER the graffing of pears upon ſpina cervina (the almoſt only purgative vegetable known in England) will produce the effect of communicating to the fruit that purging quality, or not?

4. WHETHER ſilkworms eggs will be hatched in ſuch an exhauſted receiver, in the ſeaſon proper for hatching?

To which may be added the trials of putting in a phial, full of water, ſome of thoſe herbs, that will ſhoot and grow in water alone, including them in ſuch a receiver, and pumping out what air you can, to ſee, whether they will then ſhoot or not?

AND though ſome of theſe propoſals have been formerly begun to be experimented, yet ought they to be diligently proſecuted, to ſee how far the air is neceſſary to vegetation; and whether plants do indeed live as much upon the air, as the earth; and the branches of them are rooted (as it were) in, and quickned by the air, as their roots are planted and nouriſhed in and by the earth?

THE experiment heretofore made of this kind was, that ſome lettice-ſeed being ſown upon ſome earth in the open air, and ſome of the ſame ſeed at the ſame time upon other earth in a glaſs-receiver of the above mentioned engine, afterwards exhauſted of air; the ſeed expoſed to the air was grown up an inch and a half high, within eight days; but that in the exhauſted receiver, not at all. And air being again admitted into the ſaid emptied receiver, to ſee whether any of the ſeed would then come up, it was found, that in the ſpace of one week it was grown up to the height of two or three inches.

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A CONFIRMATION of the Experiments mentioned in Numb. XXVII. to have been made by Signor FRACASSATI in *Italy*, by injecting Acid Liquors into BLOOD.

First Printed in the *Philoſophical Tranſactions*, N°. XXIX. p. 551.
For *Monday*, November 11. 1667.

THE author, having ſeen the particulars inſerted in Numb. XXVII. concerning ſome experiments made by Signor *Fracaſſati*, and recollecting, what himſelf had experimented of that nature, ſeveral years ago, was pleaſed to give to the publiſher the following information about it, by the favour of a letter, written to him from *Oxford*, October 19. 1667.

SIR,

I Hinted to you in my laſt ſomething about the original of the experiments, made in *Italy*, by injecting acid liquors into blood: to explain which, I ſhall now tell you, that about this time three years *, I mentioned at *Greſham* college to the Royal Society an odd experiment, I had formerly made (not by chance, but deſign) upon blood yet warm, as it came from the animal, *viz.* That by putting into it a little aqua fortis, or oil of vitriol, or ſpirit of ſalt, (theſe being the moſt uſual acid menſtruums,) the blood not only would preſently loſe its pure colour, and become of a dirty one, but in a trice be alſo coagulated; whereas if ſome fine urinous ſpirit, abounding in volatile ſalt, ſuch as the ſpirit of ſal armoniac, were mingled with the warm blood, it would not only not curdle it, or imbaſe its colour, but make it rather more florid than before, and both keep it fluid, and preſerve it from putrefaction for a long time.

THIS experiment I deviſed, among other things, to ſhew the amicableneſs of volatile ſpirits to the blood. And I remember it was ſo much taken notice of, that ſome very inquiſitive members of the Society came preſently to me, and deſired me to acquaint them more particularly with it; which I readily did, though afterwards I made ſome further obſervations about the ſame experiment, that I had no occaſion to relate.

THIS having been ſo publickly done, though I ſhall not ſay, that Signor *Fracaſſati* may not have hit, as well as I, upon the experiments publiſhed in his name, yet there is ſo little difference between the warm blood of an animal out of his veins and in them, that it is not very improbable, that he may have had ſome imperfect rumour of our experiment without knowing whence it came; and ſo may, without any diſingenuity, have thence taken a hint to make and publiſh, what now is engliſhed in the Tranſactions. If it be thought fit, that any mention be made of what I related ſo long ſince, I think I can ſend you ſome other circumſtances belonging to it. For I remember, I tried it with other liquors, (as ſpirit of wine, oil of tartar, oil of turpentine,) and I think alſo, I can ſend you ſome remarks upon the colour of the upper part of the blood. And I ſhall on this occaſion add, in reference to anatomical matters in general, that after I ſaw, how favourably *the Uſefulneſs of experimental Philoſophy* was received, I was invited to inlarge it in another edition; and for that, I provided divers anatomical, as well as other experiments, and deſigned many more; ſo that, I have by me divers things, that would not perhaps be unwelcome to anatomiſts, *&c.*

* The Journals of the Royal Society being looked into by the publiſher, (who, by the honour of his relation to that illuſtrious body, hath the advantage of peruſing them, as he by his office hath the care of ſeeing them faithfully managed) do fully agree with the affirmation of this noble perſon, as well in the circumſtance of the time, as the ſubſtance of the matter in queſtion; it being in the month of *December* of An. 1664. when, what is now alledged in this letter, was publickly related by its author.

New

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NEW EXPERIMENTS

Concerning the Relation between LIGHT and AIR, in ſhining Wood and Fiſh; made by the Author, and by him addreſſed from *Oxford* to the Publiſher, and ſo communicated to the ROYAL SOCIETY.

Firſt Printed in the *Philoſophical Tranſactions*, N°. XXXI. *p.* 581.
For *Monday* January 6. 166⅞.

SIR,

TO perform now the promiſe I made you the other day, I muſt acquaint you with what will perhaps ſomewhat ſurprize you, by giving you an account of what I tried on *Tueſday* night laſt (*October* 29. 1667.) and the two or three following nights, about the relation between air and light, as this is to be found in ſome bodies.

THE occaſion of theſe trials was this: Having, as you know, long ſince made ſome notes, chiefly hiſtorical, upon particular qualities, and finding light to be (how juſtly, I now diſpute not) reckoned by the generality of philoſophers among qualities, I huddled together what obſervations I had either made my ſelf, or received from ſome ingenious travellers (to whom I recommended my inquiries) about ſhining bodies; and had alſo prepared ſeveral trials about them, to be made when I ſhould have opportunity and requiſite inſtruments to put them in practice; which, as to ſome of thoſe deſigned experiments, have been long denied me. But having at length got hither one of my little engines, and having alſo procured, after much inquiry, a few ſmall pieces of ſhining wood, I began on the day above-mentioned to try with them an experiment, I found in my liſt. And though the main experiment be but one; I intend to ſet down what occurred to me about it but as ſeveral phænomena of it: yet finding it requiſite to acquaint you with ſome trials, that are not ſo properly parts of it, I ſhall, for diſtinction ſake, propoſe them as ſeveral experiments; the narratives whereof are taken, for the moſt part, *verbatim* out of the notes I ſet down for my own uſe, when the things to be regiſtered were freſhly done. Which advertiſement I give you, both to excuſe the careleſſneſs of the ſtyle, and to induce you not to diſtruſt a narrative, that was made only to ſerve my memory, not an hypotheſis.

EXPERIMENT I.

TO try, whether or no a piece of ſhining wood, being put into a receiver of our pneumatick engine, would, upon the withdrawing and re-admitting of the air, ſuffer ſuch changes, as I have often obſerved a live coal, placed there, to do. Having at length procured a piece of ſuch wood, about the bigneſs of a groat or leſs, that gave a vivid light (for rotten wood) we put it into a middle-ſized receiver, ſo as it was kept from touching the cement; and the pump being ſet a work, we obſerved not, during the five or ſix firſt exſuctions of the air, that the ſplendor of the included wood was manifeſtly leſſened, (though it never was at all increaſed;) but about the ſeventh ſuck, it ſeemed to grow a little more dim, and afterwards anſwered our expectation, by loſing of its light more and more, as the air was ſtill farther pumped out; till at length about the tenth exſuction, (though by the removal of the candles out of the room, and by black clothes and hats we made the place as dark as we could, yet) we could not perceive any light at all to proceed from the wood.

EXPERIMENT II.

WHEREFORE we let in the outward air by degrees, and had the pleaſure to ſee the ſeemingly extinguiſhed light revive, ſo faſt and perfectly, that it looked to us all, almoſt like a little flaſh of lightning, and the ſplendour of the wood ſeemed rather greater, than at all leſs, than before it was put into the receiver. But partly for greater certainty, and partly to enjoy ſo delightful a ſpectacle, we repeated the experiment with the like ſucceſs as at firſt. Wherefore being deſirous to ſee how ſoon theſe changes might be produced, we included the wood in a very ſmall receiver of clear glaſs, and found, that in this the light would begin to grow faint at the ſecond, or at leaſt at the third exſuction of the air, and at the ſixth or ſeventh would quite diſappear. And we found by a minute-watch, that the ſending the candles out of the room, the pumping out the air till the wood would ſhine no more, the re-admitting of the air, (upon which in a trice it would recover its light) and the ſending in for the candles to conſult the watch, did in all take up but ſix minutes.

EXPERIMENT III.

THE fore-mentioned experiment, without taking notice how long it laſted, being reiterated twice in this new receiver, we had a deſire to ſee, whether this luminous wood would more reſemble a coal, or the life of a perfect animal, in being totally and finally extinguiſhed, in caſe the air were kept from it a few minutes; or elſe the life of inſects, which in our exhauſted receiver I had obſerved

to

to loſe all appearance of its continuing, and that for a much longer time than a few minutes, and yet afterwards, upon the reſtitution of air, to recover preſently, and ſhew manifeſt ſigns of life? Wherefore having exhauſted the receiver, till the wood quite diſappeared, we ſtayed ſomewhat above a quarter of an hour in the dark, without perceiving, that the wood had regained any thing of light, though about the end of this time we made the place about it as dark as we could; and then it being too late at night to protract the experiment, we let in the air, upon whoſe admiſſion the wood preſently recovered light enough to be conſpicuous at a diſtance; though it ſeemed to me ſomewhat leſs vivid than before: which yet may be either a weakneſs in my ſight, or an effect of the ſteams of the cement, unfriendly perhaps to the luminouſneſs of the wood.

Thus far we proceeded yeſter-night, to which we this night added theſe obſervations.

WE put in a piece of wood bigger than the former, (this being above an inch long) and that ſhone very vigorouſly. And having by a few ſucks quite deprived it of light, we left it in the exhauſted receiver for full half an hour, and then coming into the dark room again, we found all had not continued ſo ſtanch, but that ſome ſmall portion of air had inſinuated it ſelf into the receiver. This we concluded to be but a ſmall portion of air, becauſe the wood was but viſible to an attentive eye. And yet, that it was really ſome air, which was got in, that cauſed the little glimmering light which we perceived, may appear by this, that it did preſently (as we expected) vaniſh at the firſt or ſecond ſuck; and then the air being let into the dark receiver, the included wood preſently ſhone again as before: though I ſuſpected, I diſcerned ſome little diminution of its brightneſs; which yet, till further trials of the like kind, and for a longer time, have been made, I dare not affirm. Before the receiver was ſufficiently emptied at the beginning of the experiment made with this great piece of wood, a ſmall leak accidentally ſprung, which, letting in a little air, did, ſooner than we intended, recall the almoſt diſappearing light.

EXPERIMENT IV.

THERE is an experiment of affinity with the former, which we thought it not altogether impertinent to try. For having obſerved on another occaſion, that ſometimes the operation, which the withdrawing the air hath upon a body included in the receiver, proves more conſiderable ſome minutes after we have ceaſed pumping, than immediately after the exerciſe is left off; I imagined, that even in ſuch caſes, where the light is not made wholly to diſappear (though it be made almoſt quite to do ſo) by the emptying of the pneumatical glaſs, the ſuffering the body to remain a while there, though without any pumping (unleſs now and then a very little to remove the air, that might have ſtolen in, in the mean time) the remaining light of the body might be further impaired, if not reduced quite to vaniſh. To examine this conjecture we put in a body, that was not wood, which had ſome parts far more luminous than the reſt; and having drawn out the air, all the others diſappeared, and even the formerly brighter ones ſhone but faintly, when the pneumatical glaſs ſeemed to be exhauſted. But keeping the included body a while in that unfriendly place, we perceived the parts, that had retained light, to grow more and more dim, ſome of them diſappearing, and that, which was formerly the moſt conſpicuous, being now but juſt viſible to an attentive eye, and that ſcarce without diſpute. For, if we had not known beforehand, that a ſhining matter had been included in the receiver, perhaps we ſhould not have found it out. And he, that had the youngeſt eyes in the company, could not at all diſcern it: (the air being let in, the body began to ſhine again.) But this being a ſingle trial, which the lateneſs of the night hindered us from reiterating, is to be further proſecuted, and in differing ſubſtances, before much be built upon it.

EXPERIMENT V.

THE rarefaction or expanſion of the air having ſo notable an operation upon our ſhining wood, I thought it would not be amiſs to try, what the compreſſion of the air would do to it. For which purpoſe we included a piece of it in ſuch a little inſtrument to compreſs, which you may remember to have been deviſed and propoſed by Mr. *Hook*. But though we impelled the air forcibly enough into the glaſs, yet, by reaſon of the thickneſs requiſite in ſuch glaſſes, and the opacity thence ariſing, we were not able then, to determine whether or no any change was made in the luminouſneſs of the wood.

WHICH I thought the leſs ſtrange, becauſe by ſome experiments purpoſely deviſed, (at one of which I remember you were preſent) I had long ſince obſerved, that even a great preſſure from a fluid body, which preſſeth more uniformly againſt all the parts it toucheth of the conſiſtent body, does work a far leſs manifeſt change, even on ſoft or tender ſubſtances, than one would expect from the force wherewith it compreſſeth.

AND were it not, that one contrary oftentimes minds us of another, I might have forgot, that I had divers thoughts about finding ſome good ways of trying, whether any ſuch change of texture might be diſcovered to be made in the ſhining wood by the abſence and return of the ambient air, as might with any probability have the loſs or recovery of the wood's ſplendour attributed to it. For I had formerly (if I were not miſtaken) found by ſeveral circumſtances, which I ſhall not now ſtay to name, that a ſlight (ſo it be an appropriated) variation of the texture of this wood, and which may ſeem mainly to reſpect the pores, (which perhaps ought to be of a determinate ſhape and ſize, and filled with a determinate matter) will have a great operation upon its ſplendour. And I formerly found by other trials, that even conſiſtent bodies, if ſoft

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ſoft ones, may have their pores enlarged and vitiated, and their bulk, and conſequently their texture (at leaſt as to their pores) manifeſtly enough altered by having the air withdrawn from about them, (whereby the aërial particles within them were able to expand themſelves) and let in again; whereby, as to ſenſe, they ſeemed pretty well reſtored to their former ſtate. But the ſucceſs of my endeavours either with microſcopes (through which a vivid piece of wood will ſhine by its own light) or otherwiſe, was not conſiderable enough to deſerve a particular account; eſpecially in this paper, where I am not to venture at matter of theory.

EXPERIMENT VI.

THINKING fit to try, whether a ſmall quantity of air, without being ventilated or renewed, might not ſuffice to maintain this cold fire, though it will not that of a live coal, or a piece of match, we cauſed a piece of ſhining wood to be hermetically ſealed up in a pipe of clear and thin glaſs: but though, carrying it into the dark, we found it had quite loſt its light, yet imagining, that that might proceed from its having been over-heated, (being ſealed up in a pipe not long enough to afford it a due diſtance from the flame of the lamp we employed to ſeal it,) we cauſed two or three pieces of freſh wood, amounting all of them to the length of about two inches, to be ſealed up in a ſlender pipe between four or five inches in length; which being warily done, the wood retained its light very well, when the operation was over: And afterwards laying it by my bedſide, when the candles were carried away out of the room, I conſidered it a while before I fell aſleep, and found it to ſhine vividly.

THE next morning when I awaked, though the ſun was riſen, yet forbearing to draw open the curtains of my bed, till I had looked upon the ſealed glaſs, which I had fenced with a piece of cloath, held between it and the window, my eyes having not yet been expoſed to the day-light, ſince the darkneſs they had been accuſtomed to during the night, made me think the wood ſhined brighter than ever. And this night, after ten of the clock, looking on it in a dark place, it appeared luminous all its length, though not ſo much ſo as in the morning.

THE morning after, and the night after that, the ſame wood did likewiſe manifeſtly, though not vigorouſly ſhine; eſpecially one piece, whoſe light was much more vivid than the reſt. And, for aught I know, I might have obſerved them to ſhine longer, if one of the ſealed ends of the glaſs had not been accidentally broken.

EXPERIMENT VII.

WHILST the former trials were making, I was wiſhing for a good *Bolonian* ſtone, to try what effect the withdrawing of the air would have upon it. For though I knew it might be objected, that the experiments of light performable in our engine muſt be made in the night, whereas the *Bolonian* ſtone gains its light by being expoſed to the ſun-beams; yet that objection did not hinder my wiſh, ſince the better ſort of *Bolonian* ſtones may be indued with a luminouſneſs by the flame of fire, or of large candles.

I ALSO wiſhed for ſuch a ſhining diamond, as is now in the hands, that beſt deſerve ſuch a rarity, our Royal Founder's. For you may remember, that in the obſervations I made of that ſtone, and annexed to the concluſion of the book of colours, I ſhew how it may, ſeveral ways, be brought to ſhine; ſo that by one or other of thoſe ways, eſpecially that of external heat, I thought it very likely, I ſhould be able to make the light continue four or five minutes; which would be long enough to try in a very ſmall receiver, exhauſtible at a ſuck or two, whether the withdrawing and reſtoring the air would have any viſible operation on it?

I ALSO wiſhed for ſome of the glow-worms, with which I formerly made other trials. For though I forgot not, what operation the withdrawing of the air, by our engine, is wont to have upon living creatures, yet that made me not forbear my wiſh; not only becauſe of the different effect I have found the engine to have on inſects in reſpect of other animals, but becauſe I am not of the opinion of thoſe modern writers, who will have the light of the glow-worms depend altogether upon their life, and end with it. But being not likely by my wiſhes to procure any new ſubject to make trials on, I thought fit at leaſt to do what was in my power; and accordingly (to gratify them, who, I preſumed, would, if preſent, propoſe ſuch a trial) cauſed a piece of iron to be forged, whoſe top was of the bigneſs of a nutmeg; the reſt being a ſtem, of an inch, or an inch and half long, for which we provided a little candle-ſtick of tobacco-pipe-clay, which would not yield any ſmoke to fill and darken the receiver. Then having heated the iron red-hot, and placed it in this clay, ſo that the round part was clearly protuberant, we conveyed it into a receiver of white glaſs, which was ſo placed, as to keep the ſides at as good a diſtance, as we could, from the iron, leſt the exceſſive heat ſhould (as we much feared it would) break the glaſs. Then ſending away the candles, and making the room dark, we haſtily pumped out the air, but could not perceive the withdrawing of it had any operation on the glowing iron. And though it continued ſhining long enough to give us opportunity to pump out and let in the air three ſeveral times, yet we could not obſerve, that the air had any manifeſt operation one way or other. For though, upon the withdrawing of the air, the iron grew dimmer and dimmer, yet that I attributed to the cooling of it: and the rather, becauſe, having (to examine the conjecture) let in two or three times the air, when the receiver had been exhauſted, there appeared no manifeſt increaſe of light upon the ſudden admiſſion of it.

EXPERIMENT VIII.

HAVING formerly in our *Phyſico-mechanical* experiments about the ſpring of

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the air obſerved, that the air is thus far a vehicle of ſound, that a body but faintly ſounding, being placed in our receiver, gave a yet weaker ſound, when the air was withdrawn from about it, than when the receiver was full of air; I preſumed, ſome curious perſons would, if they had been preſent, deſire to have a trial made, whether or no a ſmall piece of ſhining wood being ſo included in the receiver, as that the pumping out of the air ſhould have no injurious operation upon the body of it, its light would upon the withdrawing of the air be manifeſtly diminiſhed. And this I was the leſs backward to try, becauſe (not to mention the relation, which the former experiments ſhew there may be in ſome caſes between light and air) it did not readily occur to my memory, that by any manifeſt experiment (for I know, there are probable reaſons to prove it) it appeared, that a body more thin than air will or can tranſmit light, as well as other diaphanous mediums. And thoſe modern Atomiſts, that think, there is in our exhauſted receiver very many times more vacuum than body, would, I preſumed, be glad to be ſupplied with an argument againſt the Peripateticks, to ſhew, that the motion of bodies, *viz.* the corpuſcles of light, may be freely made *in vacuo*, and proceed without the aſſiſtance of a vehicle.

WHEREFORE having hermetically ſealed up a ſmall piece of ſhining wood in a ſlender pipe, and placed it in a ſmall receiver, that was likewiſe made of clear glaſs, we exhauſted it of air, and afterwards let in again that, which we had excluded. But by neither of the operations could we perceive any ſenſible decrement or increaſe of the light of the wood; though by that very obſervation it appeared, that the glaſs had been well ſealed, ſince otherwiſe the included air would have got out of the pipe into the receiver, and have left the wood without light.

EXPERIMENT IX.

I Had alſo a mind to try, both what degree of rarefaction of the air would deprive the wood of its ſplendour in ſuch and ſuch meaſures, and whether or no the ſelf-ſame air, which, when rarefied, would not ſuffer the wood to ſhine, would, when reduced to its former denſity, allow it to ſhine as much as before.

THIS I propoſed to do by putting ſome ſhining wood into a clear and conveniently ſhaped glaſs, that the long ſtem or pipe being ſo far filled with quick-ſilver, as that there might be about half a ſpoonful of air left at the cloſed end, where the wood was placed, it might be inverted into a little glaſs of ſtagnant quickſilver, and therewith conveyed into a ſlender receiver, out of which as the air ſhould come to be pumped, that included in the glaſs, which held the wood, might be rarefied, and afterwards upon the admiſſion of the outward air (which muſt impel up the quickſilver to its former height) might be reſtored to its former ſtate. But when we came to make trial of this, we had no receiver conveniently ſhaped, that was ſo clear and thin, as that we could ſee the wood ſhine through both the glaſſes. And though we would for an expedient have ſubſtituted a fine thin bladder, wherein the wood was to be put, and a convenient quantity of air ſtrongly tied up with it, yet for want of a bladder fine enough for our turn, that expedient alſo proved uſeleſs to us. But being deſirous to make what trial we could by the leaſt unfit means we had in our power, we got an old, but thin glaſs, ſealed at one end, whoſe ſhape was pretty cylindrical, and whoſe bore was about the bigneſs of a man's little finger, and whoſe length was about a foot or more. Into this pipe near the ſealed end we put a piece of ſhining wood, wedged in with a piece of cork, to keep it from falling; and having inverted the noſe of it into another ſlender glaſs, but not cylindrical, wherein was pretty ſtore of quickſilver, we put them both into a long receiver, ſhaped almoſt like a glaſs churn; and having pumped a while, that the air included in the pipe, expanding it ſelf, might depreſs the quickſilver, and ſo make eſcapes into the receiver, as long as we thought fit; we then let in the outward air, that the ſtagnant quickſilver might be impelled into the cavity of the pipe now freed from much of the air, to the height requiſite for our purpoſe.

THIS done, we plied the pump again, and obſerved, that, as the air in the pipe did by its own ſpring expand it ſelf more and more, and grow thinner and thinner, the ſhining wood grew dimmer and dimmer, till at length it ceaſed to ſhine, the internal air being then got a good way lower than the ſurface of the external quickſilver: whereupon opening the commerce between the cavity of the receiver, and the atmoſphere, the quickſilver was driven up again, and conſequently, the air above it was reſtored to its former denſity; upon which the rotten wood alſo recovered its light. What the greateſt expanſion of this air was, we could not certainly determine, becauſe the expanſion raiſed the external quickſilver ſo high, as to hinder us to ſee and meaſure it. But we gueſſed, that the air reached to about a foot or more from the top of the pipe to the ſurface of the quickſilver near the bottom of it. But, when that rarefied air was impelled into its former dimenſions, we meaſured it, and found, that the upper part of the tube, unpoſſeſſed by the quickſilver, was about three inches; and the wood being about an inch long, there remained two inches or ſomewhat better for the air. But this experiment is to be repeated, when exacter inſtruments can be procured.

EXPERIMENT X.

THINKING it fit to try, aswell whether ſtinking fiſh, that ſhines, be of the ſame nature as to luminouſneſs with rotten wood, that ſhines too; as whether the withdrawing of the air will extinguiſh or eclipſe the light of a conſiderable bulk of luminous matter, as in the experiments, hitherto made, we found it would do to a ſmall one; we took a fiſh, that we had

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had kept, and cauſed to be watched, till it was almoſt all over luminous; though much more in the belly and ſome parts of the head, than elſewhere: and having ſuſpended him in a conveniently ſhaped receiver, we found him to give ſo great a light, that we ſuſpected beforehand, that the withdrawing of the air would hardly have its full operation upon a body, whoſe bulk was conſiderable, as well as its light very vivid, and which had many luminous parts retired to a pretty diſtance from the air. Accordingly, having exhauſted the receiver as much as we were wont, it appeared indeed, eſpecially towards the latter end of the operation, that the abſence of the air did conſiderably leſſen, and in ſome places eclipſe the light of thoſe parts, that ſhone leſs ſtrongly. But the belly appeared not much leſs luminous than before: wherefore ſuppoſing, that upon the turning of the ſtop-cock the air coming in much more haſtily than it could be drawn out, we ſhould have the beſt advantage to diſcern, what intereſt it had in the luminouſneſs of the fiſh, we re-admitted it; and upon its ruſhing in, perceived the light to be as it were revived, and increaſed; thoſe parts of the fiſh, that were ſcarce viſible before, or ſhone but dimly, receiving preſently their former ſplendour.

AND not to leave un-proſecuted the remaining part of the experiment, which was to try, whether it was the kind of the luminous body, or only the greatneſs of the bulk, and the vividneſs of light, and, if I may ſo ſpeak, the tenacity of the ſubſtance it reſided in, that made the difference between the fiſh and the wood; we put part of the fiſh of another kind, that ſhone much more faintly than that, hitherto ſpoken of, and but in ſome places; and by the withdrawing the air, we made ſome of the luminous parts diſappear, and the others ſo dim, as ſcarce to be diſcerned; and yet both the one and the other regained their former light upon the return of the air.

AND to purſue the experiment a little further, we put in ſuch a piece of the firſt fiſh, as though it were bright, was yet but thin, and not conſiderably great; and upon pumping out the air, we found it, according to our expectation, quite eclipſed, though it recovered its light upon the air's re-entry.

THESE, Sir, are the experiments, I have lately made about the ſhining bodies in our engine. More I would have tried, notwithſtanding the trouble we found in managing the engine in the dark, if rotten wood had not failed us, and I were not in a place, where the glaſs-men's ſhops are not near ſo well furniſhed as the ſtationers.

I SCARCE doubt, but theſe experiments will occaſion among the virtuoſi ſeveral queries and conjectures, according to the differing hypotheſes, and inquiſitions, to which men are inclined. And particularly it is probable, that ſome will make uſe of this diſcourſe to countenance their opinion, that notwithſtanding the coldneſs (at leaſt as to ſenſe) of fiſhes and other animals, there may be in the heart and blood a vital kind of fire, which needs air, as well as thoſe fires, that are ſenſibly hot: which may leſſen the wonder, that animals ſhould not be able to live, when robbed of air. And if I had now time, I could poſſibly furniſh you with ſome other trials, that ſeem much to favour the compariſon, though, as to the opinion it ſelf of a vital flame, I ſhall not now tell you my thoughts about it. And though not only the Carteſians will perhaps draw an argument from the paſt phænomena in favour of their theory of light, but divers others will diſcourſe upon them, and propoſe further queſtions, and perhaps inquiries, ſuitable to their ſeveral hypotheſes; yet I ſhall content my ſelf at preſent to have faithfully delivered the hiſtorical part of theſe appearances, without making, at leaſt at this time, any reflections on them. And the rather indeed, becauſe I enjoyed ſo little health, when I was making the experiments, that it was not fit for me to engage in ſpeculations, that would much exerciſe my thoughts; which, I doubt, have been more gratified, than my health hath been by the bare trials, which are moſt ſeaſonably made at hours unſeaſonable for one, that is not well.

POSTSCRIPT, *ſent by the ſame noble Author from the ſame place*, December 6. 1667.

My condition in point of health being not much improved, ſince I writ to you in October *laſt, when I ſhall have added, that I have not theſe five or ſix weeks been able to procure any ſhining wood, (except one ſingle piece, which though large, was ſo ill conditioned, that it afforded me but one trial) you will not, I hope, expect, that I ſhould add much to the experiments I formerly ſent you about the relation betwixt light and air. But however, ſince the ſubject is new and noble, and ſince your curioſity about other mattters has been ſo welcome and uſeful to the Virtuoſi, I ſhall not decline even on this occaſion to comply with it; and the rather, becauſe I half promiſed you ſome additionals a good while ſince, and becauſe too, that though what I ſhall acquaint you with, may ſeem to be but a confirmation of two or three of the former experiments, yet, beſides that it is of them, which moſt needed a confirmation, theſe trials will alſo afford ſome circumſtances, that will not, I think, be unwelcome.*

EXPERIMENT XI.

TO examine then the conjecture, mentioned in the laſt experiment, that the durableneſs of the light in the ſhining fiſh, in ſpite of the withdrawing the air, might proceed in great part from the vividneſs of it, and the beauty of the matter it reſided in, rather than from the extent of the luminous body in compariſon of the ſmall pieces of ſhining wood, I hitherto had made my trials with; I put in the above-mentioned piece of wood, whoſe luminous ſuperficies might be perhaps ten or twelve times as great, as that, which the eye ſaw at once, of the ſurface of ſuch fragments of ſhining wood, as I was wont to imploy: and though ſome parts of this large ſuper-

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ſuperficies ſhined vividly, (for the light was uſually enough, for rotten wood, inferiour to that of our fiſh) yet this great piece, being put into a convenient receiver, was, upon the withdrawing of the air, deprived of light, as the ſmaller ones had been formerly; the returning air reſtoring its light to the one, as it had done to the other.

EXPERIMENT XII.

BUT this is not the chief thing I intended to acquaint you with; that being the ſucceſs of ſome trials, which we made in proſecution of theſe two neighbouring experiments.

IN the firſt of theſe I told you, I had been able to try but for half an hour, or a little more, that a ſhining piece of wood, deprived in our engine of light, would yet retain a diſpoſition to be as it were rekindled upon the freſh acceſs of the air. Wherefore, though I could have wiſhed to have made a further trial with the ſame kind of bodies, yet being able to procure none, I ſubſtituted in their room ſmall pieces of rotten fiſh, that ſhone ſome of them more faintly, and ſome of them more vividly, in reference to one another, but none as ſtrongly as ſome that I could have employed: and having, in a very ſmall and clear receiver, ſo far drawn off the air, as to make the included body diſappear, we ſo ordered the matter, that we kept out the air for about 24 hours; and then allowing the air to re-enter in a dark place, and late at night, upon its firſt admittance the fiſh regained its light.

EXPERIMENT XIII.

THIS, compared with ſome of my former obſervations about putrefaction, put me upon a trial, which, though it miſcarried, I ſhall here make mention of, that in caſe you, who are better furniſhed with glaſſes, think it worth while, you may get reiterated by the Society's operator. Conſidering then, how great an intereſt putrefaction hath in the ſhining of fiſhes, and air in the phænomena of putrefaction, I thought it might be ſomewhat to the purpoſe, to take a fiſh, that was, according to the common courſe I had obſerved in animals, not far from the ſtate, at which it would begin to ſhine: and having cut out a piece of it, I cauſed the reſt to be hung up again in a cellar, and the exſected piece to be put into a ſmall and tranſparent receiver, that we might obſerve, if a day or two, or more, after the fiſh in the cellar ſhould begin to ſhine, that in the exhauſted receiver would either alſo ſhine, or (becauſe that ſeemed not likely) would, notwithſtanding the check, which the abſence of the air might be preſumed to give the putrefaction, be found to ſhine too, either immediately upon the admiſſion of the air, or not long after it.

BUT this experiment, as I lately intimated, was only deſigned and attempted, not compleated; the receiver being ſo thin, that upon the exhauſtion of the internal air, the weight of the external broke it; and we could ill ſpare another of that kind from trials, we were more concerned to make: notwithſtanding which, we made one trial more, which ſucceeded no better than the former, but miſcarried upon a quite differing account, *viz.* becauſe neither the included piece of fiſh, nor the remaining, though it were of the ſame ſort with the fiſhes I uſually employed, would ſhine at all, though kept a pretty while beyond the uſual time, at which ſuch fiſhes were wont to grow luminous.

IF this experiment had ſucceeded, I had ſome others to try in proſecution of it, which I ſhall not now trouble you with the mention of. But that this paragraph may not be uſeleſs to you, I'll take this occaſion to give you a couple of Advertiſements, that may relate not only to this experiment, but alſo more generally to thoſe, whether precedent or ſubſequent, where ſhining fiſh are employed.

ADVERTISEMENT I.

IN the firſt place then, I will not undertake, that all the experiments you ſhall make with rotten fiſh, ſhall have juſt the ſame ſucceſs with theſe I have related. For, as I elſewhere obſerved, (in a diſcourſe written purpoſely on that ſubject) that the event of divers other experiments is not always certain; ſo I have had occaſion to obſerve the like about ſhining of fiſhes. And, beſides what I lately took notice of at the cloſe of the tenth Experiment, I remember, that having once deſigned to make obſervations about the light of rotten fiſhes, and having in order thereunto cauſed a competent number of them to be bought, not one of them all would ſhine, though they were bought by the ſame perſon I was wont to employ, and hung up in the ſame place, where I uſed to have them put, and kept not only till they began to putrify, but beyond the time, that others uſed to continue to ſhine; although a parcel of the ſame kind of fiſhes bought the week before, and another of the ſame kind bought not many days after, ſhined according to expectation. What the reaſon of this diſappointment was, I could not determine; only I remember, that at the time it happened, the weather was variable, and not without ſome days of froſt and ſnow. Nor is this the oddeſt obſervation I could relate to you about the uncertain ſhining of fiſhes, if I thought it neceſſary to add it in this place.

ADVERTISEMENT II.

NOTICE muſt alſo be taken in making experiments with ſhining fiſh, that their luminouſneſs is not wont to continue very many days. Which advertiſement may be therefore uſeful, becauſe without it we may be apt ſometimes to make trials, that cannot be ſoon enough brought to an iſſue; and ſo we may miſtake the loſs of light in the fiſh, to be a deprivation of it cauſed by the experiment; which indeed is but a ceſſation, according to the uſual courſe of nature.

EXPERIMENT XIV.

I KNOW not, whether you will think it worth while to be told of a trial, that we made to ſave thoſe criticks a labour, that elſe might perhaps demand, why it was not made.

We

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We put therefore a piece of ſhining fiſh into a wide-mouthed glaſs, about half filled with fair water, and having placed this glaſs in a receiver, we exhauſted the air for a good while, to obſerve, whether, when the preſſure of the air was removed, and yet (by reaſon of the water that did before keep the air from immediately touching the fiſh) the exhauſtion of the receiver did not deprive the fiſh of that contact of air, which it had loſt before; whether, I ſay, in this caſe the abſence of the air would have the ſame influence on the ſhining body, as in the former experiments; and here, as far as the numerous bubbles excited in the water would give us leave to diſcern it (for they did, though not unexpectedly, ſomewhat diſturb the experiment, which inconvenience we might have prevented, if we had thought it worth while) we could not perceive, that either the abſence or return of the air had any great operation upon the light of the immerſed body: which yet did not keep me from intending to make a ſomewhat like trial with ſhining wood (when I can get any) faſtened to the lower part of a clear glaſs, and covered over, but not very deep, with quickſilver. Of which practice I ſhall not now ſtay to give you the reaſons, having elſewhere fully enough expreſſed them.

AND that this Section may acquaint you with ſomething beſides the (ſeemingly) inſignificant experiment related in it, I ſhall here inform you, (ſince I perceive, I did not in the firſt papers I ſent you,) that though, when I formerly put together ſome notes about luminous bodies, I confined not my obſervations to one or two ſorts of fiſhes, yet the experiments, ſent you ſince *October* laſt, were all of them (except a collateral one or two) made with whitings, which among the fiſhes, I have had occaſion to take notice of, is (except one ſort, that I cannot procure) the fitteſt for ſuch trials, and conſequently fit to be named to you, to facilitate their future ones, in caſe you think it requiſite to make any upon ſuch ſubjects.

EXPERIMENT XV.

THE other of the two neighbouring experiments, I lately mentioned (*viz.* the ninth) I told you, when I ſent it you, needed a reiteration to confirm it, ſince we had but once tried it (and that without all the conveniency we deſired) that a ſhining body, which upon the firſt withdrawing the air loſeth much, but not all its light, may be deprived of the reſt by continuing in that unfriendly place, though the air be no farther exhauſted. To proſecute therefore both the experiments in one trial, we took ſomewhat late at night a piece of rotten fiſh, which we judged to ſhine too ſtrongly, to be quickly deprived of all its light, and having put it into a ſmall and clear receiver, we found (as we had foreſeen) that the light was much impaired, but nothing near ſuppreſſed by the withdrawing of the air. Wherefore having removed the receiver into a convenient place, I cauſed it to be brought to me about midnight (after I was a-bed) and having by cloſe drawing the curtains, and other means, made the place pretty dark, I perceived the included body to continue to ſhine more vividly, than one would have expected, (and, if I miſtake not, I ſaw it ſhining in the morning, whilſt it was dark;) but the night after, coming to look upon it again, its light appeared no more: notwithſtanding which I made a ſhift to keep out the air about 24 hours longer, and ſo after 48 hours in all, we opened the receiver in a dark place, and preſently upon the ingreſs of the air were pleaſingly ſaluted with ſo vivid an apparition of light, that the included body continued to ſhine, when carried into a room, where there was both fire and candle, if it were but by a hat ſcreened from their beams.

BEING encouraged, as well as pleaſed with this ſucceſs, we forthwith exhauſted the air once more out of the ſame receiver, and having kept it about four hours longer, we looked upon it again in a dark place, and finding no appearance of light, let the air in upon it, whereby it was made to ſhine again, and that vigorouſly enough, ſo that I cauſed the receiver to be exhauſted once more; but that it being *Sunday* night, I was unwilling to ſcandalize any, by putting my ſervants upon a laborious, and not neceſſary work.

THE ſuddenneſs, with which the included body appeared to be, as it were, re-kindled upon the firſt contact of the air, revived in me ſome ſuſpicions I have had about the poſſible cauſes of theſe ſhort-lived apparitions of light (for I ſpeak not now of real lamps, found in tombs, for a reaſon to be told you another time,) which diſcloſing themſelves upon men's coming in, and conſequently letting in freſh air into vaults, that had been very long cloſe, did ſoon after vaniſh. Theſe thoughts, as I was ſaying, occurred to me upon what I had been relating, by reaſon of the ſudden operation of the freſh air upon a body, that but a minute before diſcloſed no light. For, though the lights reported to have been ſeen in caves, quickly diſappeared, which that of our fiſh did not; yet that difference might poſſibly proceed from the tenacity, or ſome other diſpoſition of the matter wherein the luminouſneſs of the fiſh reſides. For I remembered, that I had more than once obſerved a certain glimmering and ſmall light to be produced in a ſort of bodies upon putting them out of their former reſt, and taking them into the air, which ſparks would vaniſh themſelves ſometimes within one minute, ſometimes within a few minutes. But as theſe thoughts were but tranſient conjectures, ſo I ſhall not entertain you any longer about them, but rather contenting my ſelf with the hint already given, take notice of what may be more certainly deduced from our experiment; which is, that the air may have a much greater intereſt in divers odd phænomena of nature, than we are hitherto aware of.

AND for confirmation of our experiment I ſhall add, that, having in another receiver eclipſed a piece of fiſh, that ſhone, when it was put in, more languidly than divers others, that we had tried, I kept it about three days and three nights in a receiver, which (receiver) being ſomewhat like another, at firſt ſuggeſted

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to me, when I came to take it, ſome ſcruple; but afterwards, upon farther examination, concluded it to be the ſame: wherefore I opened it in the dark, and upon letting in the air on this body, that ſhined but faintly at firſt, it immediately recovered its long ſuppreſſed light. And having included another piece, that was yet more faint than this, when it was put into the receiver, I thought fit to try at once the experiment hitherto confirmed, and the converſe of it. And therefore having kept this piece alſo three days and three nights in the exhauſted glaſs, I let in the air upon it, and notwithſtanding the darkneſs of the place, nothing of life was thereupon revived. But this being little other than I expected from a body, that ſhined ſo faintly, when it was put into the receiver, and had been kept there ſo long, I reſolved to exerciſe my patience a while as well as my curioſity, and try, whether the appulſe and contact of the air would have that operation after ſome time, that it had not at firſt; and accordingly, after having waited a while, I obſerved the fiſh to diſcloſe a light, which, though but dim, was manifeſt enough; but having conſidered it for ſome time, I had not leiſure to watch, whether it would increaſe, or how long it would continue.

I KNOW not, Sir, whether you are weary with reading, but I am ſure I am quite tired with making ſo many experiments upon one ſubject; and therefore I ſhall here conclude this paper, as ſoon as I have added this confirmation, as well of what I laſt related, as of ſomething, that I obſerved before, that having included in ſmall receivers two pieces of rotten whitings, whereof the one, before it was put in, ſcarce ſhone ſo vividly, as did the other after the receiver was exhauſted; and having ordered the matter ſo, that we were able to keep out the air for ſome days, at the end of about 48 hours we found, that the more ſtrongly ſhining body retained yet a deal of light. But afterwards looking upon them both in a dark place, we could not perceive in either any ſhow of light. Wherefore having let in the air into that receiver, whereinto the body that at firſt ſhined the faintlier had been put, there did not enſue any glimmering of light for a pretty while: nay, upon the ruſhing in of the air into the other glaſs, (then alſo made acceſſible to the atmoſphere) the body, that at firſt ſhone ſo ſtrongly, and that continued to ſhine ſo long, ſhewed no glimmering of light. But being reſolved to expect the iſſue a while longer, our patience was rewarded in leſs than a quarter of an hour with the ſight of a manifeſt light in the body laſt named; and a while after the other alſo became viſible, but by a light very dim. The more luminous of theſe bodies I obſerved to retain ſome light twenty-four hours after: and the hitherto recited experiment had this peculiar circumſtance in it, that the two receivers were un-interruptedly kept exhauſted no leſs than four days, and as many nights*.

Obſervations and Trials about the Reſemblances and Differences between a BURNING COAL *and* SHINING WOOD.

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THESE particulars were already in our hands, when we publiſhed the experiments made on ſhining wood and fiſh, in the laſt Papers, imparted then by the ſame noble author, that thoſe were; but wanted then room enough to contain theſe, which now follow, as they were ſent in a letter from Oxford, *viz.*

AND now, Sir, ſeeing the want of ſhining wood hath kept me ever ſince I ſent you the former experiments from making any new ones on that ſubject, I ſhall, by way of amends, ſubjoin ſome of the obſervations, that I heretofore intimated to you, I had made of the reſemblances and differences between a live coal and a piece of ſhining wood; in peruſing of which you will eaſily diſcern, that to thoſe particulars, which my memory and the former obſervations, I had noted down about light and luminous bodies, had ſuggeſted to me, I have added ſome, that have been afforded me by thoſe late trials, made in my engine, whereof I ſent you an account.

RESEMBLANCES.

THE things, wherein I obſerved a piece of wood and a burning coal to agree or reſemble each other, are principally theſe five.

1. *Both of them are luminaries, that is, give light, as having it (if I may ſo ſpeak) reſiding in them; and not like looking-glaſſes or white bodies, which are conſpicuous only by the incident beams of the ſun, or ſome other luminous body, which they reflect.*

THIS is evident, becauſe both ſhining wood and a burning coal, ſhine the more vividly, by how much the place, wherein they are put, is made the darker by the careful excluſion of the adventitious light. It is true, that the moon

* What method the noble author of theſe experiments uſed in keeping out the air for ſo long a time, will probably be made known ere long by himſelf.

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moon and Venus appear brighteſt at or about midnight, and yet have but a borrowed light; but the difference between thoſe planets and the bodies we treat of, in reference to the difficulty we are conſidering, is obvious enough. For, though the beholder's eye, that looks upon thoſe ſtars, be advantaged by being in the dark, which enlarges the pupil of the eye, yet the object it ſelf is freely expoſed to the beams of the ſun; which, if they were intercepted, thoſe planets would quickly be darkened, as experience manifeſts in eclipſes.

2. *Both ſhining wood and a burning coal need the preſence of the air, and are too of ſuch a denſity, to make them continue ſhining.*

THIS has been proved as to a coal, by what I long ſince publiſhed in my *Phyſico-mechanical Experiments*, where I relate, how quickly a coal would be extinguiſhed upon the withdrawing the air from about it: and as to ſhining wood, the experiments I lately ſent you, make it needleſs for me to add any other proof of the requiſiteneſs, not only of air, but of air of ſuch a thickneſs, to make its light continue. How far this is applicable to flame, it is not neceſſary here to determine; though when I have the ſatisfaction of ſeeing you again, I may tell you ſomething about that queſtion, which perhaps you do not expect.

3. *Both ſhining wood and a burning coal, having been deprived for a time of their light, by the with-drawing of the contiguous air, may preſently recover it by letting in freſh air upon them.*

THE former part of this particular trials have often ſhown you to be true, when kindled coals, that ſeem to be extinguiſhed in our exhauſted receivers, were preſently revived, when the air was reſtored to them: and the latter part is abundantly manifeſt by the experiments, to which this paper is an appendance.

4. *Both a quick coal and ſhining wood will be eaſily quenched by water and many other liquors.*

THE truth of this, as to coals, is too obvious to need a proof; and therefore I ſhall confirm it only as to wood. For which purpoſe you may be pleaſed to take the following tranſcript of ſome of my notes about light.

I TOOK a piece of ſhining wood, and having wetted it with a little common water in a clear glaſs, it preſently loſt all its light*.

THE like experiment I tried with ſtrong ſpirit of ſalt, and alſo with weak ſpirit of ſal armoniac; but in both the light did, upon the wood's imbibing of the liquor, preſently diſappear.

AND leſt you ſhould think, that in the words, *many other liquors*, I intended not to compriſe any, that conſiſt of ſoft and unctuous parts, or that are highly inflammable, I ſhall ſubjoin a couple of notes, that I find next to thoſe juſt now tranſcribed.

I MADE the like trial with rectified oil of turpentine, with a not unlike ſucceſs. The ſame experiment I tried more than once with high rectified ſpirit of wine, which did immediately deſtroy all the light of the wood, that was immerſed in it; and having put a little of that liquor with my finger upon a part of the whole piece of wood, that ſhone very vigorouſly, it quickly did, as it were, quench the coal, as far as the liquor reached; nor did it in a pretty while regain its luminouſneſs: (which whether it recovered at all, I know not; for this trial being made upon my bed, I fell aſleep, before I had waited long enough to finiſh the obſervation.)

5. *As a quick coal is not to be extinguiſhed by the coldneſs of the air, when that is greater than ordinary, ſo neither is a piece of ſhining wood to be deprived of its light by the ſame quality of air.*

AS much of this obſervation, as concerns the coal, will be readily granted; and for proof of the other part of it, I could relate to you more trials than one, but that I ſuppoſe, one may ſuffice, circumſtanced like that, which I ſhall now relate.

I TOOK a ſmall piece of ſhining wood, and put it into a ſlender glaſs-pipe, ſealed at one end, and open at the other, and placed this pipe in a glaſs veſſel, where I cauſed to be put a ſtrongly frigorifick mixture of ice and ſalt; and having kept it there full as long, as I thought would be requiſite to freeze an aqueous body, I afterwards took it out, and perceived not any ſenſible diminution of its light. But to be ſure, the frigorifick mixture ſhould not deceive me, I had placed by this pipe another, almoſt filled with water, which I found to be turned into ice; and though I ſuffered the wood to remain, a pretty while after, expoſed to ſo intenſe a cold, yet when I took it out, it continued ſhining, and, if I much miſtake not, it ceaſed not to do ſo, when I looked on it, twenty-four hours after. But though the light of ſhining fiſh be uſually (as far as I have obſerved) more vigorous and durable, than that of ſhining wood; yet I cannot ſay, that it will hold out againſt cold ſo well, as the other. For, having ordered one of my ſervants to cut off a good large piece of the luminous whiting, and bury it in ice and ſalt, when I called for it in leſs than half an hour after, I found it much ſtiffned by the cold, and to have no light, that I could diſcern in a place dark enough. And for fear, that this effect may have proceeded not barely from the operation of the cold, but alſo from that of the ſalt, (for which ſuſpicion you would ſee reaſon enough, if I could ſhew you my trials about ſhining fiſh) I cauſed another time a piece of whiting to be put in a pipe of glaſs ſealed at one end, and having ſeen it ſhine there, I looked upon it again, after it had ſtayed but a quarter of an hour, by my eſtimate, in a frigorifick mixture, which the glaſs kept from touching the fiſh; and yet neither I, nor a youth, that I imployed to look on it, could perceive in a dark place, that it retained any light; which whether the cold had deprived it of by that great change

* From hence you will eaſily gather the reaſon, why, when I lately told you of the trial, I made with a piece of ſhining fiſh under water in the un-exhauſted receiver, I did not propoſe to have the like trial made with ſhining wood and water, but for this liquor ſubſtituted mercury.

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change of texture, that the congelation of the aqueous juice of the fiſh (which I have ſeveral times obſerved to be luminous) may be ſuppoſed to have made in the body invaded by it; or whether the effect depend more principally on ſome other cauſe, I ſhall not now examine.

DIFFERENCES.

1. *The firſt difference I obſerved betwixt a live coal and ſhining wood, is, that whereas the light of the former is readily extinguiſhable by compreſſion (as is obvious in the practice of ſuddenly extinguiſhing a piece of coal by treading upon it) I could not find, that ſuch a compreſſion, as I could conveniently give, without loſing ſight of its operation, would put out or much injure the light even of ſmall fragments of ſhining wood:* one of my trials about which I find thus ſet down among my notes about light.

I TOOK a piece of ſhining wood, and having preſſed it between two pieces of clear glaſs (whereof the one was pretty flat, and the other convex) ſo that I could clearly ſee the wood through the glaſs, I could not perceive, that the compreſſion, though it ſometimes broke the wood into ſeveral fragments, did either deſtroy or conſiderably alter the light.

THIS experiment I repeated, with the ſame ſucceſs. But what a ſtronger or more laſting compreſſion may do in this caſe, I had not opportunity to try.

2. *The next unlikeneſs to be taken notice of betwixt rotten wood and a kindled coal, is, that the latter will in very few minutes be totally extinguiſhed by the with-drawing of the air; whereas a piece of ſhining wood, being eclipſed by the abſence of the air, and kept ſo for a time, will immediately recover its light, if the air be let in upon it again within half an hour after it was firſt with-drawn.*

THE former part of this obſervation is eaſily proved by the experiments, that have been often made upon quick coals in the pneumatical engine; and the truth of the latter part appears by an experiment about ſhining wood made by us in *October* laſt. Neither is it unprobable, that if I had had the conveniency to try it, I ſhould have found, that a piece of ſhining wood deprived of its light by the removal of the ambient air, would retain a diſpoſition to recover it upon the return of the air, not only for half an hour, (which is all that I lately aſſerted) but for half a day, and perhaps a longer time.

3. *The next difference to be mentioned is, that a live coal being put into a ſmall cloſe glaſs, will not continue to burn for very many minutes, but a piece of ſhining wood will continue to ſhine for ſome whole days.*

THE firſt part of the aſſertion I know you will readily grant; and the rather, becauſe it contains matter of fact, without at all determining, whether the coals not continuing to burn, proceeds from its being, as it were, ſtifled by its own ſmoak and exhalations, (which can have no vent in a ſmall cloſe glaſs) or from the want of freſh air, or from any particular cauſe, which I muſt not here debate; though I have ſometimes made experiments ſomewhat odd, to facilitate that enquiry. The other part of our obſervation may be eaſily made out by what I tried upon ſhining wood, ſealed up hermetically in very ſmall glaſſes, where the wood did for ſeveral days (though I remember not preciſely how many) retain its light.

4. *A fourth difference may be this; that, whereas a coal, as it burns, ſends forth ſtore of ſmoke or exhalations, luminous wood does not ſo.*

5. *A fifth, flowing from the former, is, that, whereas a coal in ſhining waſtes it ſelf at a great rate, ſhining wood does not.*

THESE two unlikeneſſes I mention together, not only becauſe of their affinity, but becauſe what concerns the coal in both, will need no proof; and as for what concerns rotten wood, it may be verified by an obſervation, that, I find by my notes, I made in a piece of it hermetically ſealed up in a ſmall clear glaſs; where, after it had continued luminous ſome days, I looked on it in the day-time to perceive, if any ſtore of ſpirits or other ſteams had, during all that while, exhaled from the wood; but could not find any on the inſide of the glaſs, ſave that in one place there appeared a kind of a dew, but conſiſting of ſuch very ſmall drops (if at leaſt their ſize were not below that name) that a multitude of them would go to the making up of one ordinary drop. But in pieces of ſhining fiſh I found the caſe much otherwiſe, as was to be expected.

6. *The laſt difference I ſhall take notice of betwixt the bodies hitherto compared, is, that a quick coal is actually and vehemently hot; whereas I have not obſerved ſhining wood to be ſo much as ſenſibly lukewarm.*

WHAT is ſaid of the coal's heat being as manifeſt as its light, I ſhall need only to make out, what relates to the ſhining wood. To aſſiſt me wherein, I meet among my notes that, whoſe tranſcript I ſhall ſubjoin, when I have premiſed, that (if my memory do not deceive me) the piece of wood to be mentioned was one, that ſhone ſo vividly, that waking in the night ſome hours before I tried it, and perceiving, as it lay near me on the bed, how luminous it was, I was invited to reach out to a place near the bed's-head, where there ſtood ſeveral books, and laying the wood on that, which came to hand, I could diſcern by the light of it, that the book was an Hebrew bible, and that of the page I lighted on, the wrong end was turned upwards: to which intimation having added, that the little glaſs inſtrument, mentioned in the note, is ſuch an one, as you may find deſcribed in my preliminaries to the hiſtory of cold, ſave that part of this was a little bending inward at the baſis, that it may ſometimes ſtand by it ſelf, and ſometimes receive a ſmall body into the dimple at its baſis: having, I ſay, premiſed this, and, that as ſhining wood did not feel at all warm to me, ſo I alſo found ſhining fiſh palpably cold, I ſhall conclude your trouble with the premiſed note, which ſpeaks thus:

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[I PUT upon a large piece of wood, which was partly ſhining, and, as near as I could, upon one of the moſt luminous parts of it, one of thoſe thermoſcopes, that I make with a pendulous drop of water. But as I had formerly tried, that by laying the tip of my noſe or finger upon it, when it ſhone vividly enough, to enable me to diſcern both the one and the other, at the time of contact I could not perceive the leaſt of heat, but rather an actual coldneſs; ſo by this trial I could not ſatisfy my ſelf, that it did viſibly raiſe the pendulous drop, though the inſtrument were ſo tender, that by approaching one finger near it, yet without actually touching of it, it would manifeſtly be impelled up, and upon the removal of my finger, would preſently deſcend again.]

AND I remember, that having put ſuch an inſtrument upon a ſhining fiſh, that was pretty large, I could not thereby perceive, that it had any degree of heat, but rather the contrary. For having divers times taken off the glaſs, to apply it with the more advantage to ſeveral parts of the luminous fiſh, I divers times (for I remember not, whether it were always) took notice, that upon the removal of the glaſs into the air, the pendulous drop would manifeſtly riſe a little, and ſubſide again, when the glaſs was applied to the fiſh. But whether this part of the experiment will hold in all temperatures of the air, I had not opportunity to try.

The End of the SECOND VOLUME.

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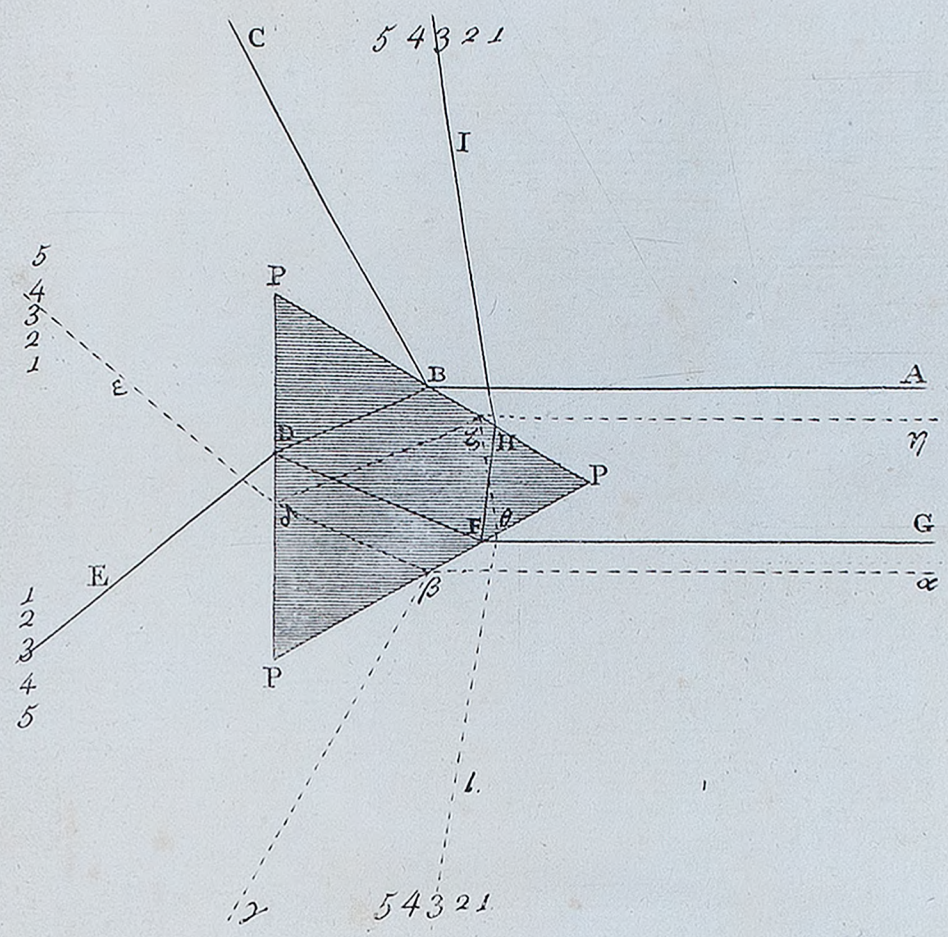
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VOL. II. *Pl. 1. p. 42.*



The Explication of the Scheme

PPP. *An Æquilaterotriangular Crystalline Prism, one of whose edges* P. *is placed directly towards the Sun*

AB & αβ *Two rays from the Sun falling on the Prism at* B β. *and thence partly reflected towards* C & γ. *and partly refracted towards* D & δ

BC & βγ: *Those reflected Rays*

BD & βδ. *Those refracted Rays which are partly refracted towards* E & ε. *and there paint an Iris* 1 2 3 4 5. *denoting the five consecutions of colours Red, Yellow, Green, Blew, and Purple; & are partly reflected towards* F & ζ.

DE & δζ. *Those Reflected Rays which are partly refracted towards* G & η. *colourless, and partly reflected, towards* H & θ.

FH & ζθ *Those Reflected Rays which are refracted towards* I & ι. *and there paint an other fainter Iris, the colours of which are contrary to the former* 5 4 3 2 1. *signifying Purple, Blew Green Yellow, Red, so that the Prism in this posture exhibits four Rainbows.*

VOL. II. *Pl. 2.*

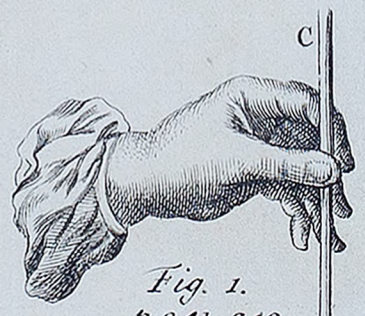
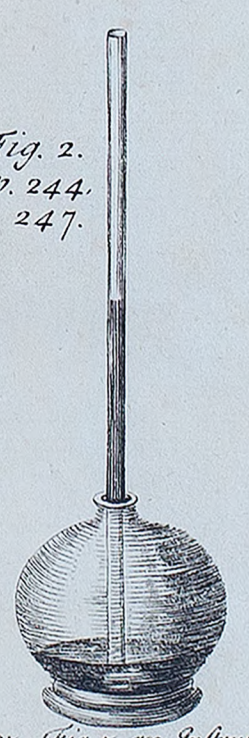


Fig. 1. p. 241, 242, 256.

Fig. 2. p. 244, 247.

Fig. 3. p. 244, 249.

Fig. 4. p. 244.



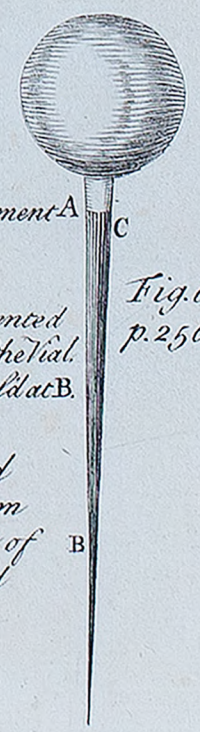
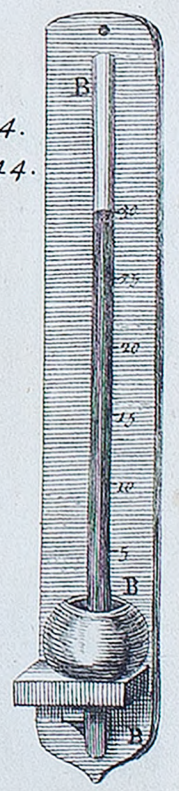


Fig. 6. p. 256.



Fig. 7. p. 257.



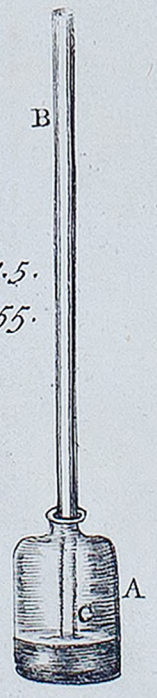


Fig. 5. p. 255.

Figure 1. in the New. page 241. 242. 256.
A. *the Ball or Egg.*
BC. *the Stem*
D. *the little Aqueous Cylinder.*

Fig. 2. the open Weather Glass p. 244. 247.

Fig. 3. the seal'd Weather Glass or Thermoscope p. 244. 249.

Fig. 4. the Barometer or Mercurial Standard placed in a Frame BB. *p. 244.*

Fig. 5. an Instrument p. 255.
A. *the Vial*
BC. *the Pipe cemented into the neck of the Vial. open at* C. & *seal'd at* B.

Fig. 6. p. 256.
A. *the Bolt head*
B. *the small Stem*
BC *the Cylinder of Water inclos'd*

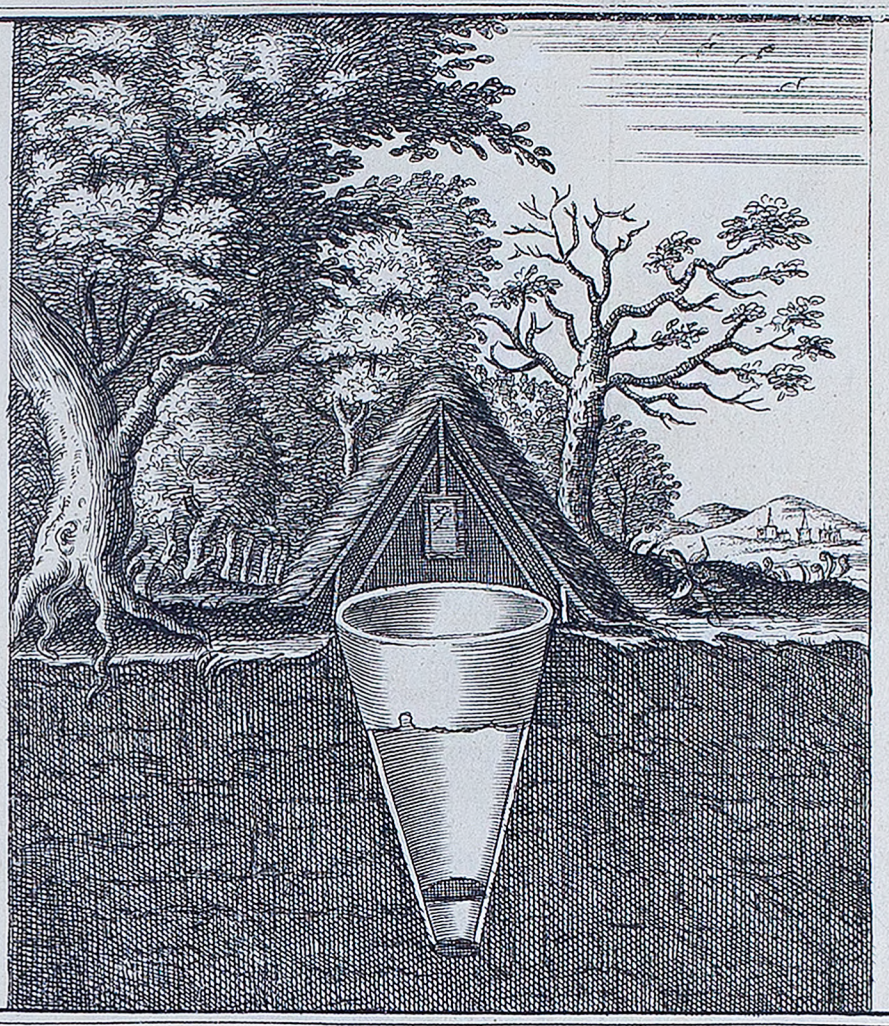
Fig. 7. p. 257.

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VOL. II. *Pl.* 3.
p. 306.



VOL. II. *Pl.* 4.
p. 403.



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Fig. 1. p. 417.

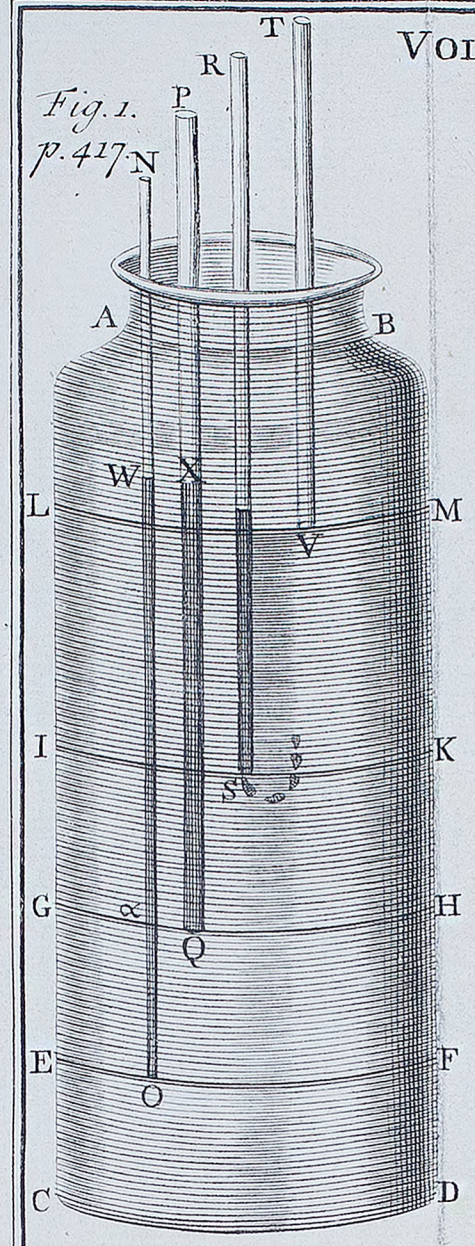


Fig. 2. p. 421.

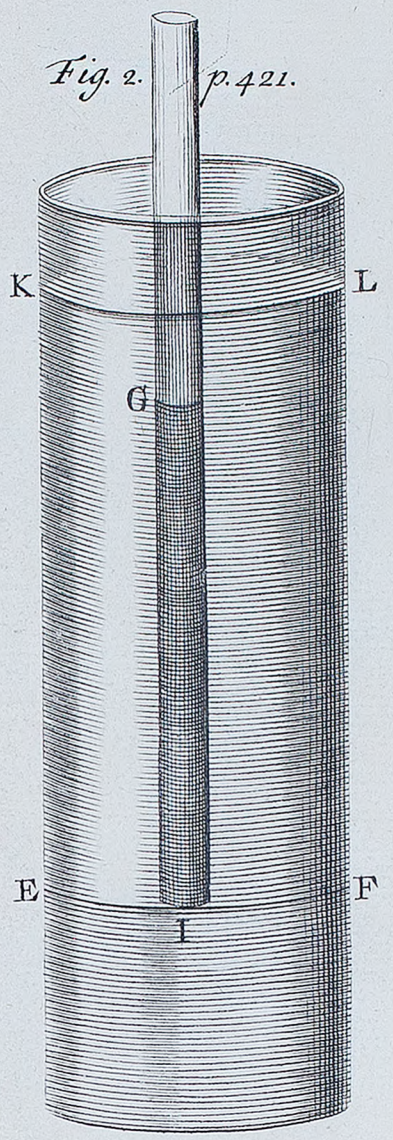


Fig. 3. p. 421.

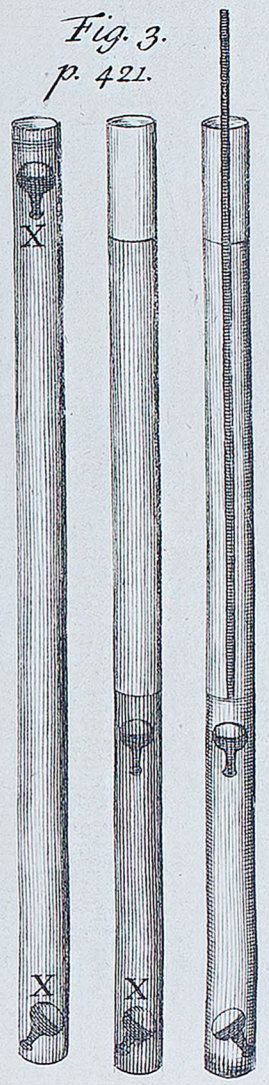


Fig. 4. p. 423

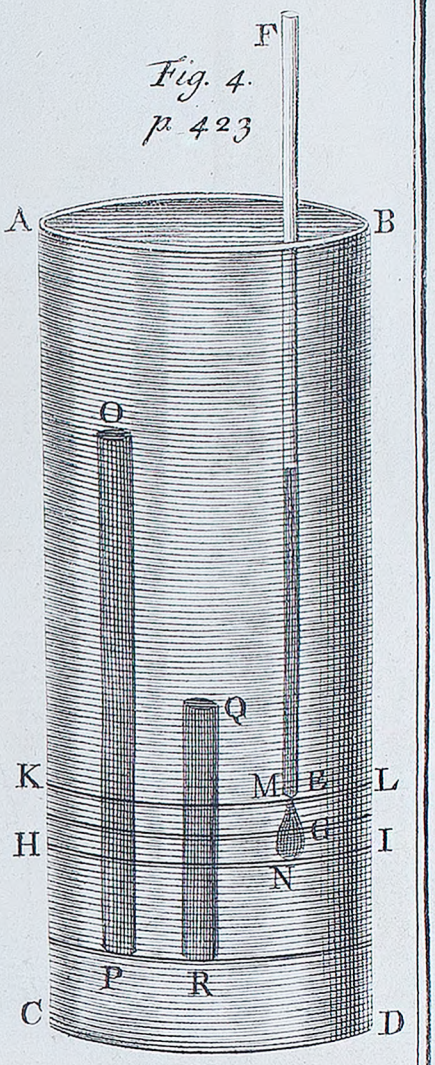


Fig. 6. p. 428.

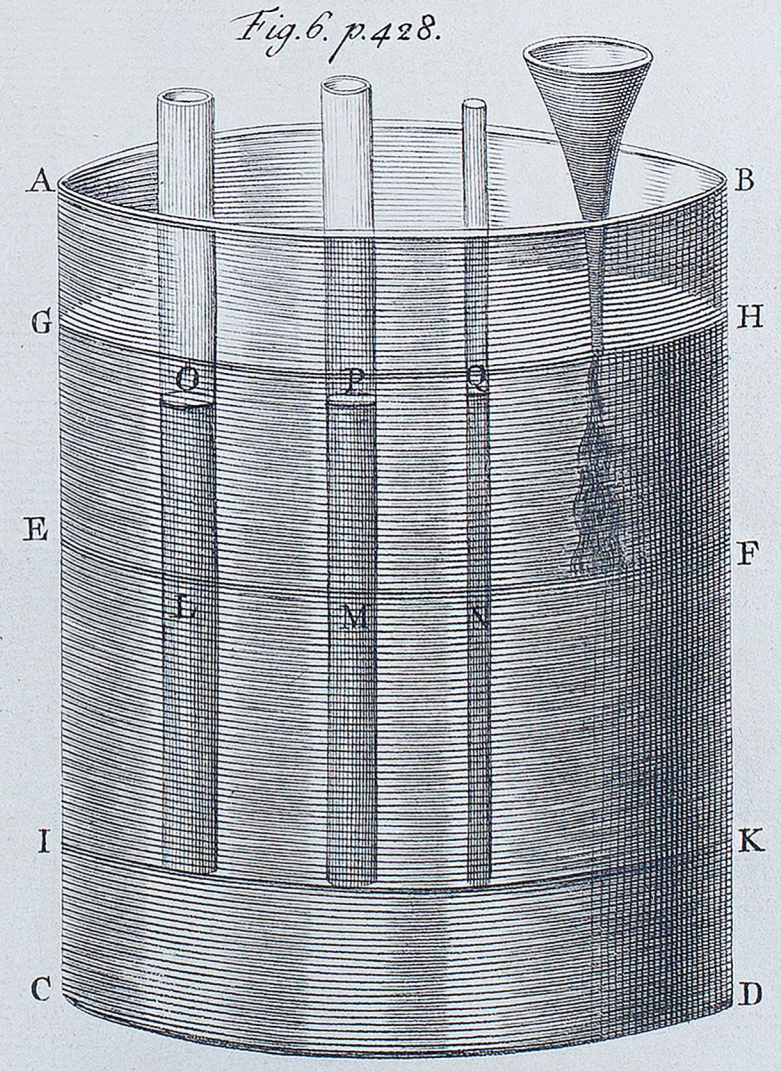


Fig. 5. p. 425.

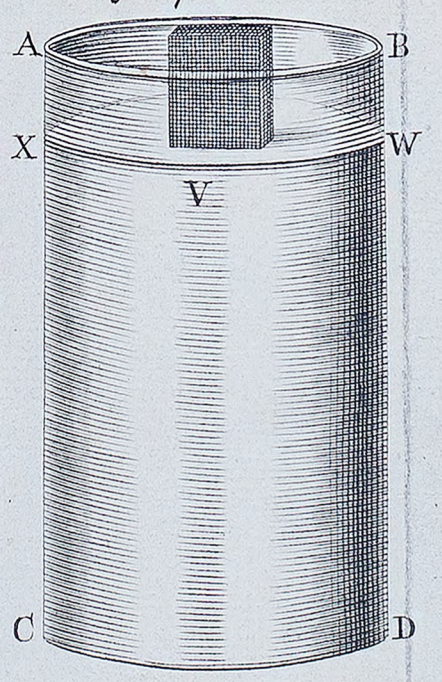


Fig. 7. p. 430.

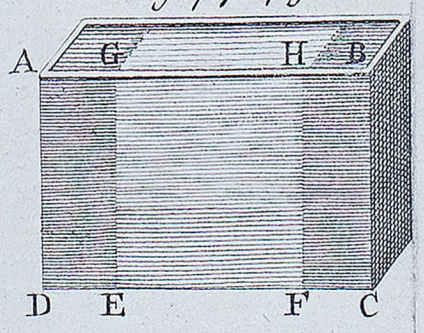


Fig. 8. p. 430.



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Fig. 9. p. 431.

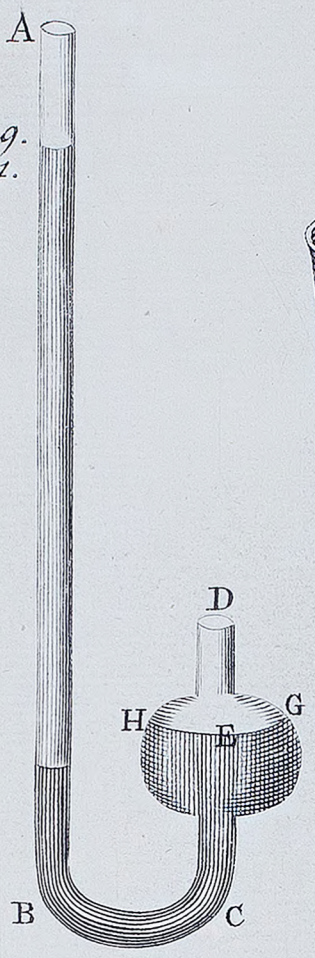


Fig. 10. p. 431.

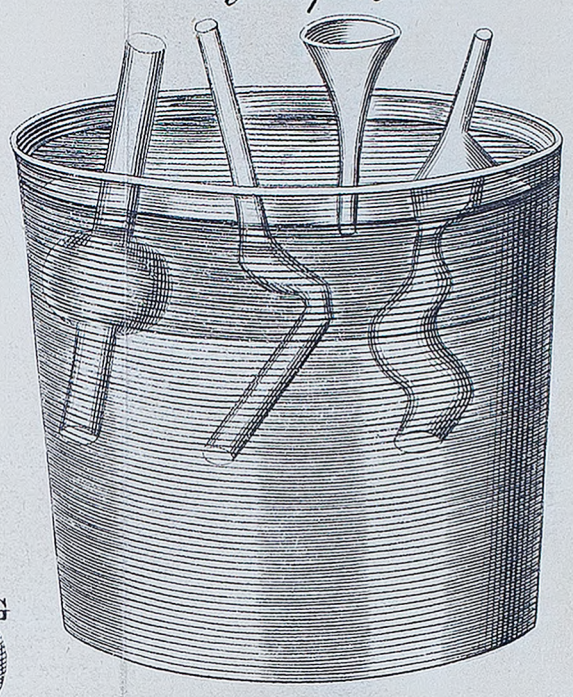


Fig. 11. p. 432.

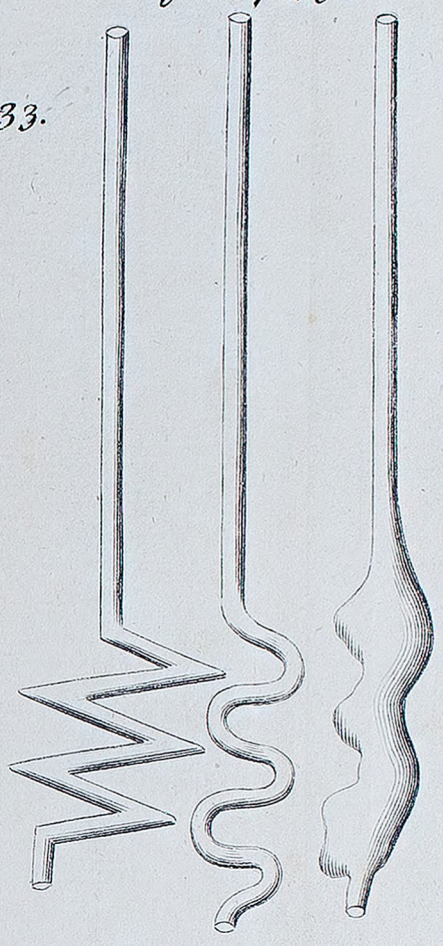


Fig. 12. p. 433.



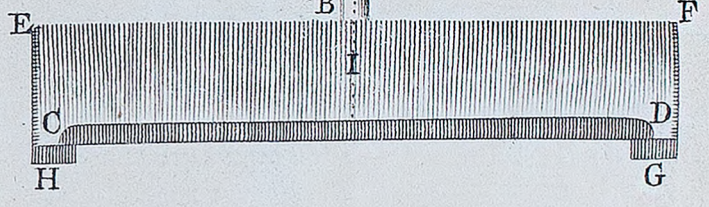


Fig. 13. p. 433.

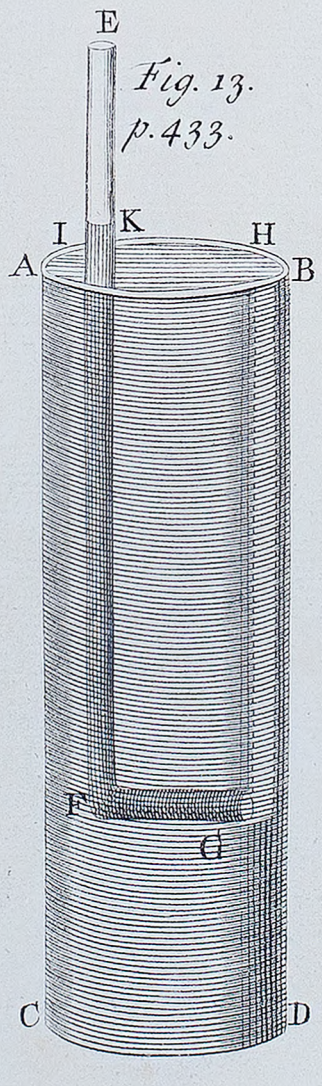


Fig. 14. p. 434.

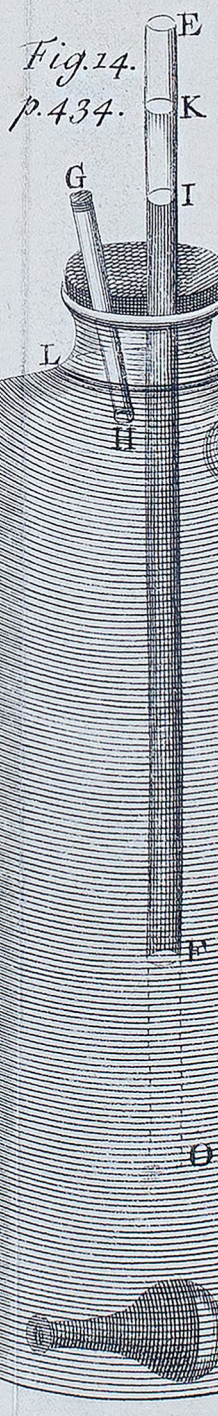


Fig. 15. p. 436.

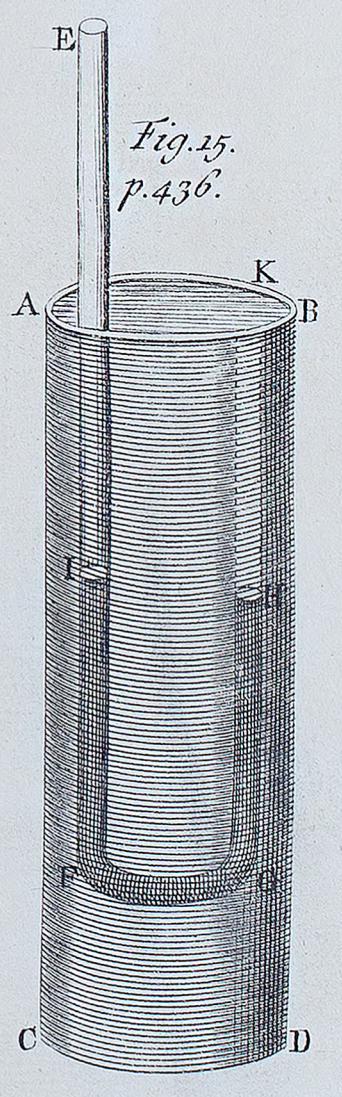
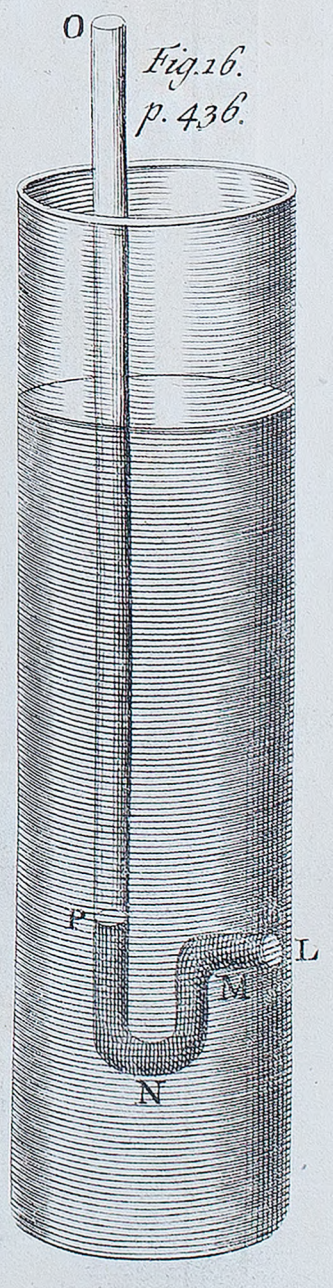


Fig. 16. p. 436.



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Fig. 17. p. 437.

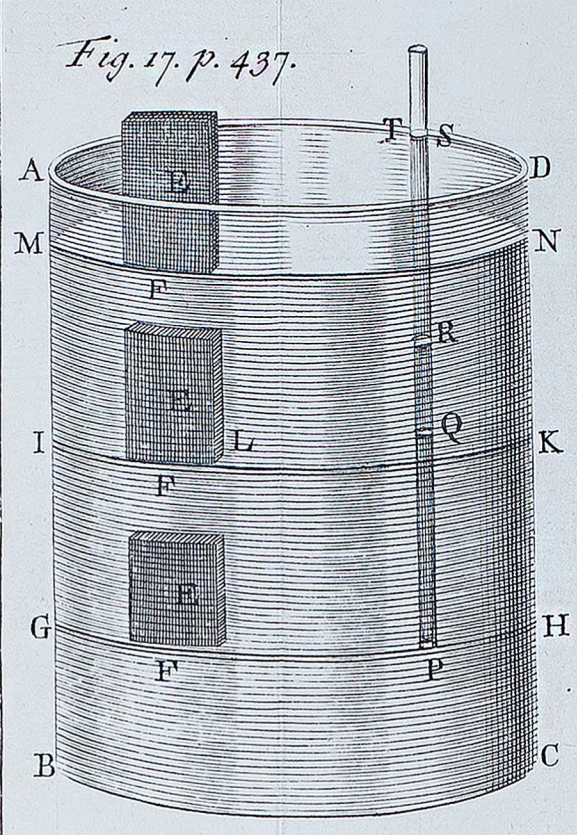


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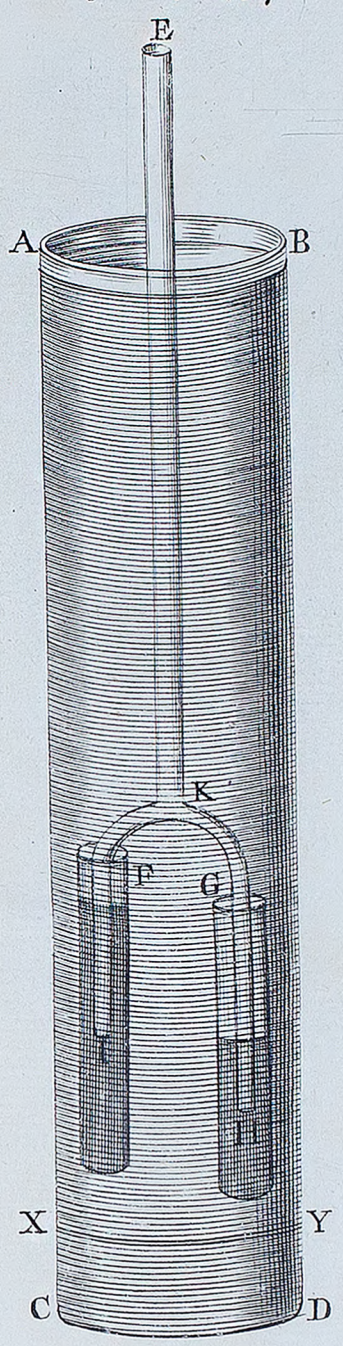


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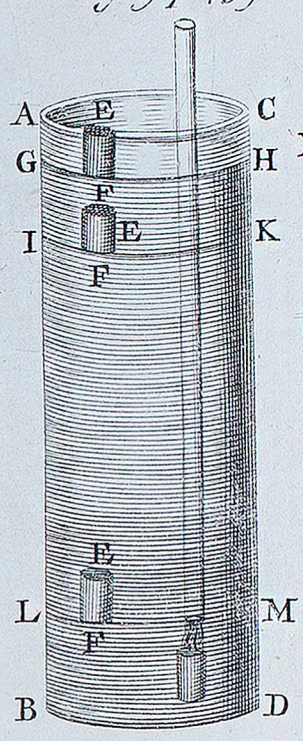


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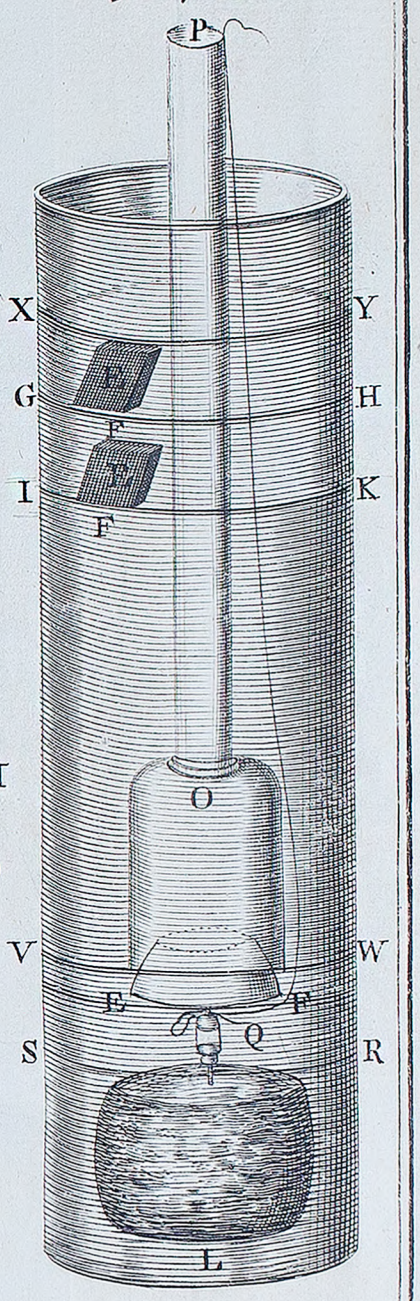


Fig. 21. p 442.

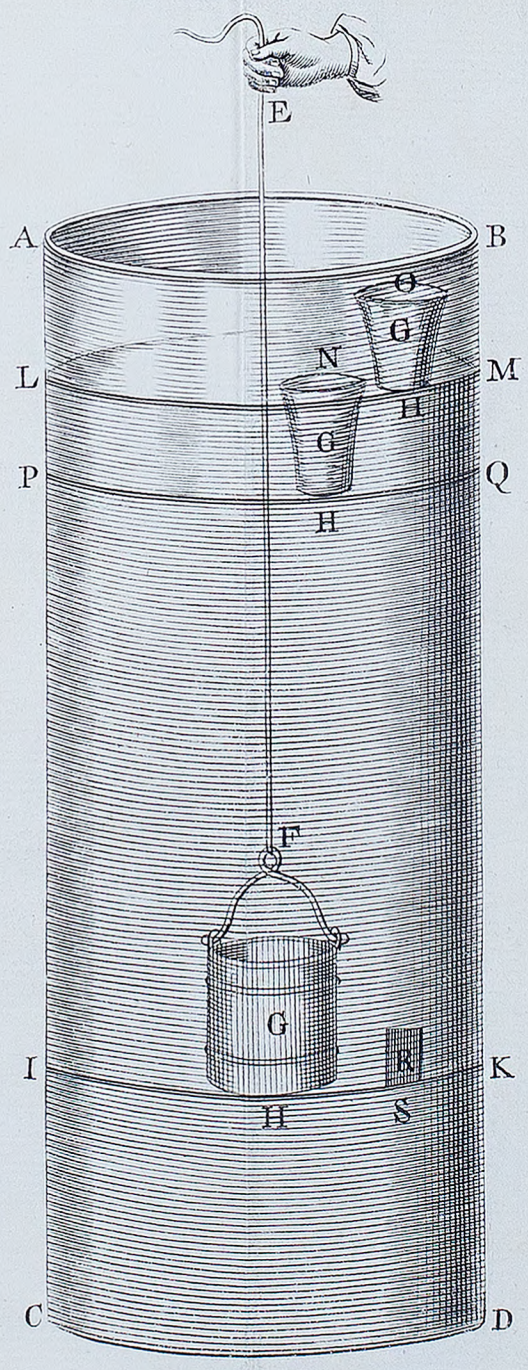


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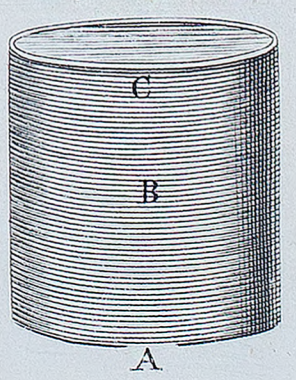


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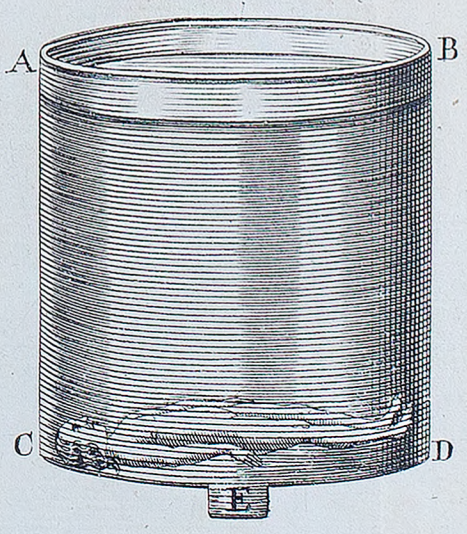
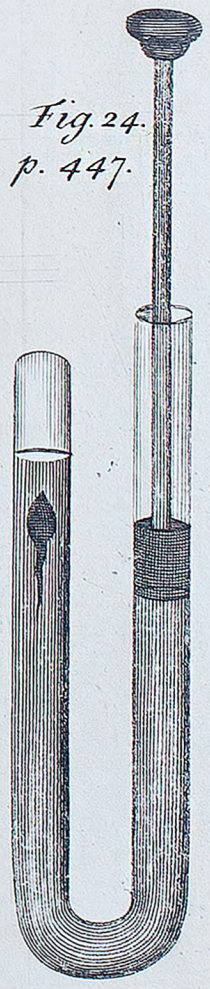


Fig. 24. p. 447.



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